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MPW C Language

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This document contains preliminary information. It does not include

- *final editorial corrections*
- *final art work*
- *an index.*

It may not include final technical changes.

Contents

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Preface

This manual provides information about Macintosh Programmer's Workshop (MPW) C that you need when writing applications, tools (programs that run under the MPW environment), and desk accessories and drivers for the Apple® Macintosh™ computer. It assumes you already know the C programming language.

In this manual you'll find information about compiler options, the libraries supplied with MPW C, and the differences between this implementation of C and other implementations.

What this manual contains

Here's a brief description of the contents of this manual:

- This Preface describes the manual and directs you to other reference books with information about the C language and the Macintosh programming environment.
- Chapter 1, "About MPW C," introduces MPW C and the C libraries; tells you about the sample programs and tells how to build a program; describes the C (compile) command and its options; tells you which include files to compile with and which library files to link with; and explains how to write applications, tools, and desk accessories.
- Chapter 2, "The MPW C Language," describes Apple extensions to C and clarifies aspects of the language definition as they apply to this implementation.
- Chapter 3, "The Standard C Library," documents a collection of basic routines that let you read and write files, examine and manipulate strings, perform data conversion, acquire and release memory, and perform mathematical operations.

- Chapter 4, "The Macintosh Interface Libraries," documents the interfaces between C and the Macintosh ROM and RAM routines. These interfaces enable you to write C programs that access the routines described in *Inside Macintosh,* Volumes 1-4.
- Appendix A, "Calling Conventions," defines the conventions for calling C and Pascal routines. It explains how parameters are passed to functions, how function results are returned, and how registers are saved and restored.
- Appendix B, "Files Supplied With MPW C," contains a list of all the files that are supplied with this product.
- Appendix C, "The Library Index," is a combined index of identifiers in the Standard C Library, the Macintosh Interface Libraries, and the C SANE™ Library.
- Appendix D, "Graf3D: Three-Dimensional Graphics," tells how to call three-dimensional graphics routines based on QuickDraw.
- Appendix E, "C Compiler Syntax," explains the syntax and options of the Compile command.

Other reference material you'll need

You'll need to be familiar with these additional reference materials:

- *Macintosh Programmer's Workshop Reference.* Apple Computer, Inc., 1986. This book describes the Macintosh Programmer's Workshop environment in which the C Compiler operates, including the Editor, Linker, Debugger, and other important tools.
- *The C Programming Language.* Brian W. Kernighan and Dennis M. Ritchie. Prentice-Hall, 1978. This is a standard reference book for the C language as originally defined.
- *C: A Reference Manual.* Samuel P. Harbison and Guy L. Steele, Jr. Prentice-Hall, 1984. This is a standard reference book for the C language with the Western Electric extensions used in most UNIX® operating system environments.
- *Inside Macintosh* (Volumes 1–3). Addison-Wesley, 1985. These volumes contain information you need in order to program using the Macintosh ROM and associated RAM routines; they cover windows, alert boxes, menus, graphics, and much more. Volumes 1 through 3 apply to all Macintoshes.
- *Inside Macintosh* (Volume 4). Addison-Wesley, 1986. This volume is about the 128K ROM routines available with the Macintosh Plus or Macintosh 512K enhanced. (Some of these routines, such as the Hierarchical File System routines, are also available on disk for machines that have the 64K ROM.)

- *Apple Numerics Manual.* Addison-Wesley, 1986. This book is for the programmer who wants more understanding or control of the underlying floating-point arithmetic in MPW C. It describes the Standard Apple Numeric Environment (SANE™), which includes extended-precision floating-point arithmetic as specified by IEEE Standard 754. It describes each routine in detail, including boundary conditions and exception handling, and explains how to control the floating-point environment.

Typographic and spelling conventions

This section describes the conventions used in this manual.

Language notation

This manual uses certain conventions in common with most books on C.

- C is in a monospace font:

```
int ndigit[10]
```

- Replaceable items in syntax diagrams are in italics:

else if *(condition)*
    statement

Here *condition* and *statement* are expressions that are replaced by actual C expressions. The `else if` and the parentheses are C code.

Boldface

Terms that are in the glossary are set in bold type when they are defined in the text. For example, "**Standard C** is Apple's name for the de facto standard definition of C."

Spelling and capitalization

In the Standard C Library, the spelling and capitalization of identifiers is exactly as specified in the synopsis for each Standard C Library routine. Most function and parameter names are spelled entirely in lowercase. Most constant values are spelled entirely in uppercase.

In the Macintosh Interface Libraries, the spelling and capitalization of identifiers is exactly as specified in *Inside Macintosh*. Constants, variables, parameter names, fields within structures, and enumerated-type elements begin with a lowercase letter. Routines and data types begin with an uppercase letter. Letters that begin new words in English are capitalized. All other letters are lowercase. When a name contains an acronym, the case of the entire acronym is determined by the case of the first letter (for example, `GetOSEvent` and `teJustLeft`).

The SANE interface follows Standard C conventions, not *Inside Macintosh* conventions.

Chapter 1

About MPW C

MPW C is a complete implementation of the C programming language. It consists of the C Compiler, the Standard C Library, the Macintosh Interface Libraries, the C SANE Library, and example programs. The C Compiler was developed by Green Hills Software. The Standard C Library is based on the standard C library used by AT&T's UNIX System V operating system. The Standard C Library provides the Integrated Environment used by MPW tools (tools and the Integrated Environment are described later in this chapter). The Macintosh Interface Libraries provide access from C programs to the routines described in *Inside Macintosh,* as well as to the Graf3D Library. The C SANE Library supports the Standard Apple Numeric Environment described in the *Apple Numerics Manual.*

About the C Compiler

The C Programming Language by Kernighan and Ritchie provides an authoritative definition of C by its creators. However, the language has changed in several ways since the book was written, and many details of the language definition are left to the implementation to define. Therefore, the de facto standard definition of C differs somewhat from the language originally defined by Kernighan and Ritchie. This de facto standard is loosely defined by the most widely used implementation of C, the Portable C Compiler (PCC).

Standard C is the term this book uses to refer to the Berkeley 4.2 BSD VAX implementation of PCC, including the documented Western Electric extensions: type `void`, enumerated data types, and structures as function parameters and results. The MPW C Compiler is based on this de facto standard (not on the proposed ANSI standard currently under development). *C: A Reference Manual* by Harbison and Steele describes Standard C thoroughly.

MPW adds these extensions to Standard C:

- the `pascal` function modifier, which allows calls to and from Pascal programs and the Macintosh Interface Libraries
- the arithmetic data types `comp` and `extended`, to support the Standard Apple Numeric Environment (SANE)

Both the Western Electric extensions and the Apple extensions to C are described in Chapter 2.

About the C libraries

The following libraries are provided with MPW C:

- The **Standard C Library** (Chapter 3) is a collection of basic routines that let you read and write files, examine and manipulate strings, perform data conversion, acquire and release memory, and perform mathematical operations. This library contains functions that support MPW tools.
- The **Macintosh Interface Libraries** (Chapter 4) are a set of interfaces between C and the Macintosh ROM and RAM routines. These interfaces enable you to write C programs that access the routines described in *Inside Macintosh,* as well as the Graf3D routines.
- The **C SANE Library** provides mathematical functions and supports floating-point arithmetic. Some of these routines are called through the Standard C Library: they are documented in Chapter 3. The other SANE routines are called through the Macintosh Interface Libraries: they are documented in Chapter 4. The semantics of these routines are described in detail in the *Apple Numerics Manual.*

Within Chapters 3 and 4, the material is alphabetical by function or library name. All of the identifiers defined in the libraries are listed in a combined library index in Appendix C.

A list of the library object files used with MPW C appears in Table 1-1. The first three files, provided with the Macintosh Programmer's Workshop, are shared with other languages and are found in the {Libraries} directory. The remaining files, provided with MPW C, are used only with C and are found in the {CLibraries} directory.

Table 1-1
Library object files used by MPW C

Libraries shared with other languages—{Libraries} directory	
Interface.o	*Inside Macintosh* libraries shared with other languages
ToolLibs.o	Routines normally used by tools, including the spinning cursor and error manager
DRVRRuntime.o	Runtime support for desk accessories and other drivers

Table 1-1 (continued)
Library object files used by MPW C

C Libraries—{CLibraries} directory	
CInterface.o	*Inside Macintosh* libraries specifically for C
StdCLib.o	Standard C Library
CRuntime.o	Execution starting point for applications and tools, data initialization, Quickdraw data, low-level I/O, signal handling, and built-in routines
CSANELib.o	SANE numerics for C
Math.o	Math functions, including conversions, exponential and logarithmic functions, trigonometric functions, and hyperbolic functions

About the C examples

The {CExamples} directory contains source files for a sample application, MPW tool, and desk accessory written in C. These files are listed in Table 1-2.

Table 1-2
Example source files used by MPW C

Source files—{CExamples} directory	
Instructions.c	Instructions for building sample programs.
Makefile.c	Make file for building sample programs.
Sample.c	Sample application. This is the sample application described in the section "A Simple Example Program" in Chapter 1 of *Inside Macintosh,* Volume 1.
Sample.r	Resources for sample application.
Count.c	Sample MPW tool. This is the source for the Count tool supplied with MPW and documented in the *Macintosh Programmer's Workshop Reference,* Chapter 9.
Memory.c	Sample desk accessory. The Memory desk accessory displays the current free space in the application and system heaps, the free space on the default volume, and the name of the default volume. This information is updated every five seconds. When Memory is first opened, it calls _MaxMem to purge memory, thus showing the upper bounds on free space in the heaps.

Table 1-2 (continued)
Example source files used by MPW C

Source files—{CExamples} directory	
Memory.r	Resources for sample desk accessory.
Stubs.c	Stubs for library routines not used by MPW tools. The presence of these stubs allows the Linker to reduce the size of a tool.

The file Instructions.c contains step-by-step instructions for building each of the sample programs. After installing MPW and MPW C, as described in the *Macintosh Programmer's Workshop Reference,* open this file and follow the instructions.

Installing MPW C

Instructions for installing MPW on a hierarchical file system (HFS) hard disk (such as the Apple Hard Disk 20), on the Macintosh XL, and on 800K disks are found in Chapter 1 of the *Macintosh Programmer's Workshop Reference*. After installing MPW by following those instructions, install C as follows:

Hard disks	**800K**
Copy file C (the Compiler) to the {MPW}Tools: folder. Copy the folders CExamples, CIncludes, and CLibraries to the {MPW} folder.	Copy file C and the folders CExamples, CIncludes, and CLibraries to an 800K disk. Name the disk *C*. Remember to use Startup.800K as your startup file, following the instructions in the *Macintosh Programmer's Workshop Reference*. After you have examined the examples in folder CExamples, you may want to discard them to create more space on the disk.

❖ *Note:* You can put the Compiler, includes, and libraries in different directories, provided you change the default values of various Shell variables defined in the Startup file. You can modify the file Startup itself or, preferably, modify the file UserStartup. The following variables determine the locations of files supplied with MPW C:

{Commands}	A comma-separated list of directories containing tools and applications. The directory containing the C Compiler should appear on this list.
{CIncludes}	The directory containing C include files. This should be the pathname of the CIncludes directory.
{CLibraries}	The directory containing C library files. This should be the pathname of the CLibraries directory.

For more information, see "Variables" in Chapter 3 of the *Macintosh Programmer's Workshop Reference.*

Creating an application in C

An **application** is a program that can be run under the Macintosh Finder. Applications can also be run from the MPW Shell: execution of the MPW Shell is suspended and the application takes over the computer's memory and display while executing.

The code for an application is contained in `'CODE'` resources in the resource fork of its file. Additional resources in the same file describe the menus, windows, dialogs, strings, and other resources used by the application. ***Inside Macintosh*** explains in detail how to write a Macintosh application. The following sections outline how to create an application using MPW C.

Compiling an application

To compile a C program, first start the MPW Shell application, then enter the C command in any window. Typically the command will specify options and the name of the source file to the Compiler, although neither is required. For example, the command

```
C  -p  Sample.c
```

compiles the source file Sample.c, producing the object file Sample.c.o. The -p option specifies that progress information should be written to standard output. This information will appear after the command.

If you enter the command

```
C
```

(that is, the C command without a filename), the Compiler reads from standard input—this means that the Compiler reads any text that you subsequently enter. This allows you to run the Compiler interactively. You can tell that the Compiler (rather than the MPW Shell) is reading the text you enter because the name "C" appears in the status box in the lower-left corner of the active window. Once the Compiler is running interactively, you can enter source code in any window, composing your program as you go. To terminate input, press the Command and Enter keys simultaneously. When the Compiler compiles standard input, it creates an object file named C.o.

❖ *Note:* It can be very confusing if you accidentally run the Compiler interactively. If you get the impression that the MPW Shell isn't listening to the text you enter, check the status box in the lower-left corner of the top window. It contains either the name of the Shell (if the Shell really is listening) or the name of the command that is currently executing.

A complete specification of the C command—including input, output, and diagnostic specifications, status values, and options—is found in Appendix E.

Include files

Include files (often called *header files*) are provided for both the Standard C Library and the Macintosh Interface Libraries. These files are in the {CIncludes} directory. You can determine what header files to include for a particular library function or data structure by checking the Synopsis of the appropriate section in Chapters 3 and 4.

The Compiler will search several directories for include files, until the specified file is found. The directories to search are determined by the directory containing the current input file, directories specified using the `-i` option to the Compiler, and directories specified in the Shell variable {CIncludes}.

Filenames in `#include` statements can be enclosed in either double quotation marks or angle brackets:

```
#include "MyFile.h"
#include <Types.h>
```

Normally double quotation marks are used for include files you create, and angle brackets for include files supplied with MPW. The search rules the Compiler uses in looking for the include file differ slightly in the two cases.

The form of the pathname also determines where the Compiler looks for the include file. If a *full pathname* is specified, it's the exact name of the file and no search is performed. Full pathnames contain at least one colon (:) but don't begin with a colon. If a *partial pathname* is specified, the Compiler searches several directories for the file. Partial pathnames either begin with a colon or don't contain any colons.

Table 1-3 summarizes the Compiler's include-file search rules.

Table 1-3
Include-file search rules

Full pathnames	
`#include` "*filename*"	Use the name as specified.
`#include` <*filename*>	Use the name as specified.
Partial pathnames	
`#include` "*filename*"	Search the following directories, in this order: 1. Item

2. The directory of the source file that contains the `#include` statement
3. Directories specified by the Compiler's `-i` option, in the order specified
4. Directories specified by the Shell variable {CIncludes}

`#include` <*filename*>	Search the directory listed above in steps 2, 3, and 4.

Segmentation control

A **segment** is one or more functions that can be separately loaded into memory. Your program can be written without explicit segmentation, or it can contain a number of different segments. At run time, a segment is automatically loaded by the Segment Loader when you call one of its functions. The segment is not unloaded until you explicitly unload it by calling `UnLoadSeg`. See *Inside Macintosh* for more information about the Segment Loader.

Each `'CODE'` resource in the application's resource fork corresponds to a segment containing one or more functions. (The `'CODE'` resource with ID 0 contains the jump table; other `'CODE'` resources contain functions.) When the application is executed, each segment is automatically loaded into memory by the Segment Loader when a call is made to one of the routines in the segment. The segment is not unloaded until the application explicitly unloads it by calling `UnLoadSeg`. See the Segment Loader chapter in *Inside Macintosh*, Volume 2, for more information.

There are several ways to specify which functions are placed in which segments. This section tells how to use the Compiler's `-s` option and the `__SEG__` directive to specify segmentation. The *Macintosh Programmer's Workshop Reference* explains how to use the Link command to modify a program's segmentation.

Segmentation helps you reduce your program's runtime memory requirements. A typical segmentation algorithm divides a program into an initialization segment and a main processing segment. You can also put routines that are seldom executed—printing routines, for instance—in a separate segment that is not loaded when the program begins executing. This causes the program to be loaded faster, because the printing routines are not loaded until they are needed. If you don't specify segmentation, the Compiler puts the entire program into a segment called **Main** unless you override the default name with the `-s` compiler option.

The define directive `__SEG__` lets you specify several segments within a single source file. To assign source code to a segment, precede the code with a statement of the form

`#define __SEG__` *segmentname*

The code following this statement is placed in the named segment until the __SEG__ symbol is redefined or the Compiler reads the end of the source file.

❖ *Note:* In the #define directive, segment names are case sensitive. Leading and trailing spaces are significant. Unless you want the segment name to start or end with spaces, leave exactly one space between __SEG__ and *segmentname* and no spaces after *segmentname*.

Code for a given segment does not have to be contiguous within the source file. The program may take the form

```
#define __SEG__ SegA
  ...function...
#define __SEG__ SegB
  ...function...
  ...function...
#define __SEG__ SegA
  ...function...
etc.
```

The Compiler marks each function with the name of its segment. Then the Linker collects functions for a segment from various input files and places them in a single segment in the output file.

Creating resources

Noncode resources, such as the resources that specify menus, windows, and dialogs, can be created using the Resource Editor (ResEdit) and the Resource Compiler (Rez). These tools are described in the *Macintosh Programmer's Workshop Reference.*

Linking an application

The Linker is used to combine object files from several separate compilations, together with any necessary library object files, to produce the executable code resources for a program. The Linker will either create a new resource file, containing only the code resources for your program, or replace the code resources in an existing resource file, leaving other resources, such as menus and dialogs, intact. This allows you to run the Resource Compiler either before or after running the Linker. The Linker is described in detail in the *Macintosh Programmer's Workshop Reference.*

An application written partly or totally in C should be linked with the libraries listed below.

***Inside Macintosh* interfaces**	**Runtime support**	**Standard C Library**
{Libraries}Interface.o {CLibraries}CInterface.o	{CLibraries}CRuntime.o	{CLibraries}StdCLib.o {CLibraries}CSANELib.o {CLibraries}Math.o

It's wise to link new programs with all the libraries that might be appropriate. If unnecessary files are specified, the Linker will display a warning indicating they can be removed from your build instructions.

Programs written partly in C and partly in assembly language or Pascal should be linked with the file CRuntime.o and not the file Runtime.o. The Linker will detect several duplicate entry points when linking with both the Pascal and the C libraries. All but one of these duplicates can be safely ignored: the copies of the routines are identical. The `-w` option in the Linker can be used to suppress the duplicate-definitions warnings.

The exception is the execution starting point. If execution is expected to begin with the C function `main()`, no special precautions are necessary. However, if your main program is written in assembly language or Pascal but parts of your program are written in C (and must therefore be linked with file CRuntime.o), the object file containing your main program must appear before CRuntime.o in the list of object files passed to the Linker.

A C program that calls a Pascal function or procedure requires an `extern pascal` declaration. (See the section "Pascal-Compatible Functions" in Chapter 2.)

Creating an MPW tool in C

A **tool** is a program that operates within the MPW Shell environment. The C Compiler, Rez, and Link are all tools. You can write your own tools in C, Pascal, or assembly language. The *Macintosh Programmer's Workshop Reference* manual describes tools and how they are created. This section contains specific information about writing tools in C.

You execute a tool by entering an MPW command. The parameters specified in the command line are passed as parameters to the function `main()`. The Shell variables that are exported are also passed as a parameter to `main()`; they can be accessed directly or by using the `getenv()` function from the Standard C Library. To access these parameters, declare function `main()` as follows:

```
main(argc, argv, envp)
     int argc;              /* number of arguments */
     char *argv[];          /* pointer to array of argument strings */
     char *envp[];          /* pointer to array of variable definitions */
```

Additional details regarding parameters to tools may be found in the *Macintosh Programmer's Workshop Reference.*

Tools have direct access to MPW Shell windows and selections. The `FILE` variables `stdin`, `stdout`, and `stderr` refer to MPW's standard input, standard output, and diagnostic output respectively. By default, Standard C Library I/O functions read standard input (text entered from the Shell) and write to standard output. Any files opened by tools, using either Standard C Library functions or ***Inside Macintosh*** library functions, will read and write to windows if the file specified is open in a window. The contents of the window are read or written in place of the data fork of the file. Selections in windows can also be read and written as if they were files, by adding the suffix **.§** to the filename (for example, HD:MPW:Worksheet.**§**).

Compiling a tool

You compile a tool in exactly the same way you compile an application. The information above regarding include-file search rules, segmentation, and resources applies equally to tools and applications.

Linking a tool

The MPW Shell recognizes a tool by the type and creator. Specify the following options when linking a tool:

```
Link -t MPST -c "MPS " ...
```

The instructions above describing what library files to link with applications also apply to tools. In addition, if your tool calls any of the spinning cursor or error manager routines, you'll need to link with the following library:

```
Tool Library
      {Libraries}ToolLibs.o
```

The Integrated Environment

Tools use the Integrated Environment routines, provided as part of the Standard C Library; these routines enable a tool that calls them to run either under the MPW Shell or under the Finder. For more information about the Integrated Environment, see the *Macintosh Programmer's Workshop Reference.*

The Standard C Library routines that provide Integrated Environment facilities are `close`, `creat`, `dup`, `faccess`, `fcntl`, `getenv`, `lseek`, `open`, `read`, `signal`, `unlink`, and `write`.

These routines have C calling conventions, and their string parameters are assumed to be null-terminated C strings.

Creating a desk accessory in C

A **desk accessory** is a program run using the Apple menu. It shares its execution environment with the currently executing application. Information on writing desk accessories can be found in the Desk Manager and Device Manager chapters of *Inside Macintosh* and in the *Macintosh Programmer's Workshop Reference*. The following sections contain information specific to writing desk accessories in MPW C.

Desk accessory restrictions

A desk accessory has neither a jump table nor a global data area. Because it does not have a jump table, all of the code must be in a single segment. Either omit segmentation specification so that all your code is placed in the default Main segment, or use identical segmentation specifications for all of your functions. Use the Link command to move any library routines you use into your single segment.

Because it does not have a global data area, a desk accessory written in C may not use `extern` or `static` variables, or literal strings. Furthermore, a desk accessory cannot call library routines that require global data. Programming hints for avoiding these restrictions can be found in the *Macintosh Programmer's Workshop Reference*.

❖ *Note:* Apple is investigating the use of A5-based global variables in desk accessories in a future release of MPW. (Some other development systems use register A4 for this purpose. This precludes the use of library routines that depend on A5.) Currently, several Macintosh applications contain trap override or ROM hook routines that expect A5 to point to the application's globals, without saving, setting, and restoring A5 to insure that this is the case. This is incompatible with desk accessories that use A5 because calls to the ROM from the DA may end up in the application's trap override or hook code.

The DRVRRuntime library

Desk accessories have traditionally been written in assembly-language source, partly because of the peculiar resource format used by the system for desk accessories, the `'DRVR'` resource. Setting up the `'DRVR'` layout header, passing register-based procedure parameters, and coping with the nonstandard exit conventions of the driver routines have made it fairly difficult in the past for programmers not familiar with assembly language to implement desk accessories in higher-level languages.

To overcome these difficulties and simplify the task of writing a desk accessory in C, MPW provides the library DRVRRuntime.o and the resource type `'DRVW'` declared in MPWTypes.r. Together they compose the driver layout header and the five entry points that set up the `open`, `prime`, `status`, `control`, and `close` functions of a driver. For more information about `'DRVR'` resources, see the Device Driver chapter of *Inside Macintosh,* Volume 2.

There are several advantages to using library DRVRRuntime.o in creating desk accessories. No assembly-language source is required. Each of the driver routines—DRVROpen, DRVRPrime, DRVRStatus, DRVRControl, and DRVRClose—can be written in C using standard calling conventions. The DRVRRuntime library handles desk accessory exit conventions: your routines simply return a result code.

The DRVRRuntime library consists of a main entry point that overrides the C runtime main entry point. The DRVRRuntime entry point contains driver "glue" that sets up the parameters for you, calls your routine, and performs the special exit code required by a desk accessory to return control to the system. Your routines perform the actions of the desk accessory, such as opening a window or responding to mouse clicks in it.

Desk accessory routines

Desk accessories that use the library DRVRRuntime must contain the five functions DRVROpen, DRVRPrime, DRVRStatus, DRVRControl, and DRVRClose. All of these functions have the same parameter and result types. They are declared as Pascal-compatible functions so that the library DRVRRuntime may be used for writing desk accessories in C, Pascal, and assembly language. Each of these five routines should be declared as follows:

```
pascal OSErr DRVROpen(ctlPB,dCtl)
        CntrlParam *ctlPB;
        DCtlPtr dCtl;
{
        ...your code here...
        return(resultCode);
}
```

Types `CntrlParam` and `DCtlPtr` are defined in the file Devices.h. Type `OSErr` is a `short` and is defined in Types.h. Details on what each of these functions should do are found in the *Macintosh Programmer's Workshop Reference.*

Linking a desk accessory

A desk accessory written in C must be linked with both DRVRRuntime.o and CRuntime.o. DRVRRuntime.o must precede CRuntime.o in the list of object files passed to the Linker.

```
Desk Accessories
      {Libraries}DRVRRuntime.o
```

Chapter 2

The MPW C Language

The information provided in this chapter supplements *The C Programming Language* by Kernighan and Ritchie.

Where Kernighan and Ritchie's language definition leaves choices to the implementers, this chapter describes how these aspects of C have been implemented on the Macintosh. Where Apple has modified or extended their language definition, this chapter documents the changes.

Language definition

This section describes the MPW C language, including language extensions such as type `void`, type `enum`, the SANE data types, and calling Pascal-compatible functions.

Variable names

The Compiler does not place a limit on the length of local variable names. Global variable names and function names are limited to 63 characters by the object-module format. Therefore, different function names whose first 63 characters are identical will be treated as different functions by the Compiler but will be treated as the same function by the Linker.

Data types

Table 2-1 lists the arithmetic and pointer types available in MPW C and shows the number of bits allocated for variables of these types. Types `int` and `long`, which are identical in this implementation, represent 32-bit integers. Pointers also require 32 bits. Enumerated types are allocated 8, 16, or 32 bits, depending on the range of the enumerated literal values.

Table 2-1
Size and range of data types

Data type	Bits	Description
`char`	8	range –128 to 127
`unsigned char`	8	range 0 to 255
`short`	16	range –32,768 to 32,767
`unsigned short`	16	range 0 to 65,535
`int`	32	range –2,147,483,648 to 2,147,483,647
`unsigned int`	32	range 0 to 4,294,967,295
`long`	32	range –2,147,483,648 to 2,147,483,647
`unsigned long`	32	range 0 to 4,294,967,295
`enum`	8, 16, or 32	depends on the range of the enumerated literals
`*`	32	pointer types
`float`	32	IEEE single-precision floating point
`double`	64	IEEE double-precision floating point
`comp`	64	SANE signed integral values
`extended`	80	IEEE extended-precision floating point

Note: Type `short int` is equivalent to `short`, and type `long int` is equivalent to `long`.

Numeric constants

Integer constants in the range of `long` are treated as type `long`. Integer constants outside the range of `long` are treated as type `extended`, not type `unsigned long` as you might expect. For example, the initialization statement

```
long i = 4000000000;
```

is incorrect because 4,000,000,000, being too big for a `long`, is interpreted as an `extended` value. However, the the initialization statement

```
unsigned long i = 4000000000;
```

is correct because 4,000,000,000 is within the range of `unsigned long`.

Type void

The **`void`** keyword tells the Compiler that the function being declared does not return a value. Calls to functions of type `void` may not be used in expressions, where a value is required. (See "Pascal-Compatible Functions" later in this chapter.)

Type `void` can also be used in a cast to explicitly discard the return value of a function call, as in

```
(void) printf("Hello");
```

Type enum

Type **enum** is a type analogous to the enumerated types of Pascal. Its syntax is similar to that of the `struct` and `union` declarations:

enum-specifier:
    `enum` { *enum-list* }
    `enum` *identifier* { *enum-list* }
    `enum` *identifier*
enum-list:
    enumeration-declaration
    enumeration-declaration, *enum-list*
enumeration-declaration:
    identifier
    identifier = *constant-expression*

The first identifier in ***enum-specifier***, like the structure tag in a `struct` specifier, names a particular enumeration. For example,

```
enum color {chartreuse, burgundy, claret, winedark};
enum color *cp, col;
```

These declarations make `color` the enumeration tag of a type describing various colors and then declares `cp` as a pointer to an object of that type and `col` as an object of that type.

The identifiers in ***enum-list*** are declared as constants and may appear wherever constants are required. If no ***enumeration-declarations*** with a ***constant-expression*** appear, the values of the constants begin at 0 and increase by 1 as the declaration is read from left to right. An ***enumeration-declaration*** with a ***constant-expression*** gives the associated identifier the value indicated; subsequent identifiers continue the progression by 1 from the assigned value.

Enumeration constants must be unique. They are drawn from the set of ordinary identifiers, unlike field names in structures. Objects of a given enumerated type have a type distinct from objects of all other types.

Enumerated types are allocated the amount of space required by the smallest predefined type that allows representation of all the literal values specified by the enumeration. The predefined types are `char` and `unsigned char` (8 bits), `short` and `unsigned short` (16 bits), and `int` and `unsigned int` (32 bits). The `-z6` compiler option overrides the allocation algorithm and forces the Compiler to allocate 32 bits for all enumerated data types.

Important

If you use the `-z6` option, your enumerated types will not match data structures used in the Macintosh ROM.

Register variables

The Compiler allocates automatic variables in registers whenever possible. Register variables will be assigned to registers before other automatic variables. Enumeration, character, integer, and pointer variables qualify for register allocation unless their address is taken with the & operator. Floating-point variables are not allocated to registers.

Several data and address registers are available for use as automatic variables. The exact number depends on the calling conventions used. The number of variables allocated to registers may exceed the total number of registers. Several variables whose useful lifetimes do not overlap may be assigned to the same register. Often all of the eligible variables within a function will reside in registers, rather than on the stack.

Structures

Structures may be assigned, passed as parameters, and returned as function results. Other operators, such as equality comparison, are not available for structures.

The left and right sides of a structure assignment must have the same type. Similiarly, actual and formal parameters must have identical types.

Important

Functions that return structures are not reentrant. If an interrupt occurs during the return sequence and the same function is called during the interrupt, the value returned from the first call may be incorrect. The problem can occur only in the presence of interrupts. Recursive calls are quite safe.

The newline, carriage-return, and vertical-tab characters

The **newline** character in output advances the print position or cursor to the left margin on the next line. In C notation, newline is represented by `\n`. The character code for `\n` in this implementation is the ASCII value (13) for the carriage-return character, not the ASCII value (10) for the linefeed character, as in most other implementations.

In C notation, the **carriage-return** character is represented by `\r`. The character code for `\r` in this implementation is the standard ASCII value (13) for the carriage-return character. Therefore `\r` and `\n` are equal in MPW C, although they are not equal in most other implementations.

The vertical-tab character (ASCII 31), represented by \v, is not meaningfully interpreted in Editor windows or by TextEdit.

Reserved symbols

__LINE__ is a reserved preprocessor symbol whose value is the current line number within the current source file.

__FILE__ is a reserved preprocessor symbol whose value is a character string consisting of the current filename.

__SEG__ is a reserved preprocessor symbol that overrides the segment name associated with functions that follow; it remains in effect until the next __SEG__ directive. The default segment name, Main, may also be overridden with the -s compiler option.

__LINE__, __FILE__, and __SEG__ begin and end with two underscore characters.

Predefined symbols

The following symbols are predefined for use in conditional compilation:

```
MC68000
mc68000
m68k
ghs
macintosh
```

Each of the predefined symbols has the value 1, as if a statement of this form had appeared at the beginning of the source code:

```
#define MC68000 1
```

The -u compiler option lets you undefine any of the predefined symbols.

Standard Apple Numeric Environment extensions

MPW C has built-in support for the Standard Apple Numeric Environment (SANE). SANE is introduced in this section and documented completely in the *Apple Numerics Manual.* Chapters 3 and 4 of this book include the interface to the C SANE Library, which supplements the SANE facilities built into the MPW C language. Because the C SANE Library provides a number of functions, such as exp, that are found in the Standard C Library, the interfaces to these functions appear in Chapter 3, "The Standard C Library." Additional functions appear in Chapter 4, "The Macintosh Interface Libraries."

The MPW C language and the C SANE Library together implement the IEEE Standard for Binary Floating-Point Arithmetic (754). SANE adds a data type to the IEEE types and provides basic functions for application development. MPW C recognizes the SANE data types (`float`, `double`, `comp`, and `extended`), uses SANE for all floating-point operations and conversions, and correctly handles NaNs (Not-a-Number) and infinities in comparisons and in ASCII-binary conversions. Furthermore, source programs written using only Standard C `float` and `double` types and Standard C operations are portable—they will compile and run in MPW C as well as in other C implementations.

Much of SANE is provided through the runtime library CSANELib.o and its include file SANE.h. However, to use extended-precision arithmetic efficiently and effectively and to handle IEEE NaNs and infinities, some extensions to Standard C are required, including the use of the `extended` data type.

The change from `double` to `extended` as the basic floating-point type is the most important difference from Standard C. Because C was originally developed on the DEC PDP-11, the PDP-11 architecture is reflected in Standard C in the use of `float` and `double` as floating-point types, with `double` as the basic type: floating-point expressions are evaluated to `double`, anonymous variables are `double`, and floating-point parameters and function results are passed as `doubles`. However, the low-level SANE arithmetic (as well as the floating-point chips Intel 8087, Motorola 68881, and Zilog Z8070) evaluates arithmetic operations to the range and precision of an 80-bit `extended` type. Thus, `extended` naturally replaces PDP-11 `double` as the basic arithmetic type for computing purposes. The types `float` (IEEE `single`), `double`, and `comp` serve as space-saving storage types, just as `float` does in conventional C.

The IEEE Standard specifies two special representations for its floating-point formats: NaNs (Not-a-Number) and infinities. MPW C expands the syntax for I/O to accommodate NaNs and infinities, and includes the treatment of NaNs in relationals as required by the IEEE Standard.

The SANE extensions to Standard C are backward compatible: programs written using only `float` and `double` floating-point types and Standard C operations compile and run without modification. SANE does not affect integer arithmetic.

Constants

Numeric constants that include floating-point syntax—a point (.) or an exponent field—or that lie outside the range of type `long` are of type `extended`. Decimal-to-binary conversion for numeric constants is done at compile time and hence is governed by the default numeric environment (see "Numeric Environment" in this chapter).

Expressions

The SANE types—`float`, `double`, `comp`, and `extended`—can be mixed in expressions with one another and with integer types in the same manner that `float` and `double` can in Standard C. An expression consisting solely of a SANE-type variable, constant, or function is of type `extended`. An expression formed by subexpressions and an arithmetic operation is of type `extended` if either of its subexpressions is. `Extended`-type expressions are evaluated using extended-precision SANE arithmetic, with conversions to type `extended` generated automatically as needed. Parentheses in `extended`-type expressions are honored. Initialization of external and static variables is done at compile time; all other evaluation of `extended`-type expressions is done at run time.

Comparisons involving a NaN

The result of a comparison involving a NaN operand is **unordered.** The usual set of comparison results—less than (<), greater than (>), and equal to (==)—is expanded to include unordered. For example, the negation of "*a* less than *b*" is not "*a* greater than or equal to *b*" but "(*a* greater than or equal to *b*) OR (*a* and *b* unordered)."

Functions

A numeric actual parameter passed by value is an expression and hence is of `extended` or an integer type. All `extended`-type arguments are passed as `extended`. Similarly, all results of functions declared `float`, `double`, `comp`, or `extended` are returned as `extended`.

Numeric input/output

In addition to the usual syntax accepted for numeric input, the Standard C Library function `scanf` recognizes the string "`INF`" as infinity and the string "`NAN`" as a NaN. "`NAN`" may be followed by parentheses, which may contain an integer (a code indicating the NaN's origin). "`INF`" and "`NAN`" are optionally preceded by a sign and are case insensitive. The `scanf` specifiers for SANE types extend Standard C as follows: conversion characters `f`, `e`, and `g` indicate type `float`; `lf`, `le`, and `lg` indicate type `double`; `mf`, `me`, and `mg` indicate type `comp`; and `ne`, `nf`, and `ng` indicate type `extended`.

The Standard C Library function `printf` writes infinities as "`INF`" and NaNs as "`NAN`(*ddd*)", where *ddd* is the NaN code. "`INF`" and "`NAN`(*ddd*)" may be preceded by a minus sign.

Numeric environment

The numeric environment comprises the rounding direction, rounding precision, halt enables, and exception flags. IEEE Standard defaults—rounding to nearest, rounding to extended precision, and all halts disabled—are in effect for compile-time arithmetic (including decimal-to-binary conversion). Each program begins with these defaults and with all exception flags clear. Functions for managing the environment are included in the C SANE Library (CSANELib.o). The Compiler, in optimizing, will not change any part of the numeric environment (including the exception-flag setting, which is a side effect of arithmetic operations).

About the C SANE Library

The C SANE Library provides the basic tools for developing a wide range of applications. It includes the following:

- logarithmic, exponential, and trigonometric functions
- financial functions
- random-number generation
- binary-decimal conversion
- numeric scanning and formatting
- environment control
- other functions required or recommended by the IEEE Standard

See Chapters 3 and 4 for the interface to the C SANE Library.

Programming with IEEE arithmetic

MPW C's automatic use of the `extended` type produces results that are generally better than those of most other C systems. For example, extended precision yields more accuracy, and extended range avoids unnecessary underflow and overflow of intermediate results. You can further exploit the `extended` type by declaring all floating-point temporary variables to be of type `extended`. This is both time-efficient and space-efficient, because it reduces the number of automatic conversions between types. External data should be stored in one of the three smaller SANE types (`float`, `double`, or `comp`), not only for economy but also because the `extended` format may vary between SANE implementations. As a general rule, use `float`, `double`, or `comp` data as program input; `extended` arithmetic for computations; and `float`, `double`, or `comp` data as program output.

In many instances, IEEE arithmetic allows simpler algorithms than were possible without IEEE arithmetic. The handling of infinities enlarges the domain of some formulas. For example, $1+1/x^2$ computes correctly even if x^2 overflows. While running with halts disabled (the default), a program will never crash because of a floating-point exception. Hence by monitoring exception flags, a program can test for exceptional cases after the fact. The alternative of screening out bad input is often infeasible, and sometimes impossible.

Pascal-compatible functions

The function-calling conventions used by MPW C and Pascal differ in the order of parameters on the stack, the type coercions applied to parameters, the location of the return result, and the number of scratch registers. C has been extended to allow function calls between these languages. The `pascal` specifier in a function declaration or definition indicates a **Pascal-compatible function.**

Pascal-compatible function declarations

A function or procedure written in Pascal (or written in C or assembly language following Pascal calling conventions) can be called from C. This section tells you how to declare Pascal-compatible functions in C. Appendix A describes both the C calling conventions and the Pascal-compatible calling conventions.

A Pascal-compatible external function declaration begins with the `pascal` specifier; contains the usual type specifiers, function name, and parameter list; and must contain declarations for the parameters, followed by the word `extern`. Pascal-compatible function declarations are external declarations—that is, they may not appear within functions or compound statements. Parameters whose declarations are omitted are assumed to be type `int`.

Here is an example of a procedure, `DrawText`, as defined in Pascal:

```
PROCEDURE DrawText(textBuf: Ptr; firstByte, byteCount: Integer);
```

Here is the corresponding C function declaration for the `DrawText` procedure. Note that the declaration contains the `void` keyword because in Pascal a procedure does not return a value.

```
pascal void DrawText(textBuf, firstByte, byteCount)
        Ptr textBuf;
        short firstByte, byteCount;
        extern;
```

Pascal-compatible function declarations are used in the Macintosh Interface Libraries to allow C programs to directly call Macintosh library routines that use Pascal calling conventions. The word `extern` may be followed by a constant, which is interpreted as a 16-bit 68000 instruction that replaces the usual subroutine call (JSR) instruction in the calling sequence. This allows direct traps to the Macintosh ROM. For example,

```
pascal void OpenPort(port)
        GrafPtr port;
        extern 0xA86F;
```

Pascal-compatible function definitions

A C function definition (the actual function), like a function declaration, can also be preceded by the `pascal` specifier. The function is then given Pascal-compatible calling conventions by the Compiler. For example, the following C function can be called from Pascal:

```
pascal void MyText(byteCount, textAddr, numer, denom)
        short byteCount;
        Ptr textAddr;
        Point numer, denom;
        {
                ...
        }
```

The corresponding Pascal function declaration is

```
PROCEDURE MyText(bytecount: integer; textAddr: Ptr; numer, denom: Point);
```

For compatibility with Pascal and assembly language, the Compiler converts the names of Pascal-compatible functions to uppercase before writing them to the object file. When they are called in C programs, these routines should be capitalized exactly as they were declared in C. Pascal-compatible functions whose names differ only in their capitalization will become duplicate declarations when their names are converted to uppercase by the Compiler; therefore such names should be avoided.

Parameter and result data types

C and Pascal support different data types. Therefore when writing a Pascal-compatible function declaration in C, a translation of the parameter types and function-result type (from Pascal to C) is required. Often this translation is obvious, but some cases are surprising. For example, Pascal passes type `char` as a 16-bit value.

Table 2-2 summarizes this translation. Find the Pascal parameter or result type in the first column. Use the equivalent C type found in the second column when declaring the function in C. Comments in the table point out unusual cases that may require special attention.

Table 2-2
Parameter and result data types

Pascal data type	C equivalent	Comments
`boolean`	`boolean`	`Boolean` is defined in file Types.h as `enum {false,true}`:
`VAR boolean`	`boolean *`	In C, `false` is zero and `true` is often considered nonzero.
`boolean` result	`boolean`	In Pascal, `false` is zero and `true` is one.
enumeration type (<128 or >255 literals)	`enum`	Use identical ordering of the enumeration literals.
enumeration type (128 to 255 literals)	`short`	Pascal passes enumerations with 128 or more literals as words.
`VAR` enumeration type (<128 or >255 literals)	`enum *`	
`VAR` enumeration type (128 to 255 literals)	`short *`	
enumeration-type result (<128 or >255 literals)	`enum`	
enumeration-type result (128 to 255 literals)	`short`	
`char`	`short`	Pascal passes `char` parameter as 16-bit values.

var char	short *	Pascal stores unpacked char types as 16-bit values.
char result	short	
integer	short	16-bit signed values.
VAR integer	short *	
integer result	short	
longint	int or long	32-bit signed values.
VAR longint	int * or long *	
longint result	int or long	
real	extended *	Pascal passes real parameters as extended by address.
VAR real	float *	
real result	float	Pascal returns real results by value.
double	extended *	Pascal passes double parameters as extended by address.
VAR double	double *	
double result	double	The caller supplies the address of the double result.
comp	extended *	Pascal passes comp parameters as extended by address.
VAR comp	comp *	
comp result	comp	The caller supplies the address of the comp result.
extended	extended *	Pascal passes extended parameters by address.
VAR extended	extended *	
extended result	extended	The caller supplies the address of the extended result.
pointer type	pointer	32-bit addresses.
VAR pointer type	pointer *	
pointer-type result	pointer	

ARRAY (1 or 2 bytes)	short	Pascal passes small arrays by value.
ARRAY (3 or 4 bytes)	int or long	
ARRAY (5 or more bytes)	array	Pascal passes larger arrays by address.
VAR ARRAY	array	
ARRAY result	—	C does not allow arrays as results.
RECORD (1 to 4 bytes)	struct	Pascal passes small records by value.
RECORD (5 or more bytes)	struct *	Pascal passes larger records by address.
VAR RECORD (any size)	struct *	
record result (1 or 2 bytes)	struct	Pascal returns small records by value.
RECORD result (3 or 4 bytes)	struct	
RECORD result (5 or more bytes)	struct	The caller supplies the address of the record result.
SET (1 to 7 elements)	char	Pascal passes sets with 1 to 7 elements as bytes.
SET (8 to 16 elements)	short	Pascal passes sets with 8 to 16 elements as words.
SET (≥17 elements)	struct	Pascal also passes larger sets by value.
VAR SET (1 to 7 elements)	char *	
VAR SET (8 to 16 elements)	short *	
VAR SET (≥17 elements)	struct *	
SET result (1 to 7 elements)	char	Pascal returns small sets by value.

SET result (8 to 16 elements)	short	
SET result (≥17 elements)	struct	The caller supplies the address of the set result.

❖ *Note:* The C `struct` type and the Pascal `record` type do not exactly correspond, as C lacks an equivalent to the Pascal `variant record` type. You can see the relationship by comparing the data structures in the Files section of Chapter 4 with those in the File Manager chapter of *Inside Macintosh,* Volume 4.

Global and external data types

When a C program and a Pascal program use the same global or external variables, they must use the corresponding data types. These are shown in Table 2-3. The first column shows the Pascal type. The second column shows the equivalent C types (sometimes there are more than one).

Table 2-3
Global and external data types

Pascal data type	C equivalent	Comment
`boolean`	`boolean`	Defined in file Types.h
enumeration type	`enum`	
`char`	`short`	
`-128..127`	`char`	
`0..255`	`short`	
`integer`	`short` or `unsigned short`	
`longint`	`int`, `unsigned int`, `long`, or `unsigned long`	
`real`	`float`	
`double`	`double`	
`comp`	`comp`	
`extended`	`extended`	
pointer type	`pointer`	
`STRING`	`Str255`	Defined in file Types.h

Implementation notes

A number of details in every C language definition are left to the discretion of the implementers. Most programs do not rely on these details and therefore yield the same results on the various implementations. However, if you want to write programs that will run under more than one implementation, you need to know the specific semantics of each C compiler. This section explains several areas of the language definition that are specific to MPW C.

Size and byte alignment of variables

Variables of type `char`, and variables of type enum that require only a single byte of memory, are aligned in memory on byte boundaries. All other types are aligned on word boundaries: that is, they have even memory addresses. Note that `struct` types are aligned on word boundaries, and that the smallest `struct` (a `struct` with one char in it) takes up two bytes. The packing of enum types is described in the "Type Enum" section in this chapter. Signed and unsigned types have the same size and alignment.

Byte ordering

The Macintosh's microprocessor, the Motorola 68000, stores the least significant byte of a short or long integer at the highest memory address. This byte ordering is also used on IBM System/370 and Zilog Z8000 processors. The 6502 family of processors used in the Apple II family of computers, the Intel 8086 family, the PDP-11 family, the DEC VAX, and the National Semiconductor NS16000 store the least significant byte at the lowest address. Programs that rely on the order of the bytes within short and long integers will not work correctly on both classes of machines.

Variable-allocation strategy

The MPW C Compiler optimizes allocation of variables in various ways. Automatic variables (locals) are allocated in registers whenever possible. Static and global variables are not necessarily allocated in the order in which they are specified. (However, the order of fields within structures is preserved.) Static variables may be allocated as if they were automatic if their values are always set before being referenced. Automatic and static variables that are never used may not be allocated at all. Programs should not rely on the Compiler's allocation algorithms.

Types unsigned char, unsigned short, and unsigned long

Types `unsigned char`, `unsigned short`, and `unsigned long` are supported by the MPW C Compiler and by many implementations of PCC, although they are not required by the basic C language definition. The VAX implementation of PCC and the MPW C Compiler differ in the way they evaluate expressions involving these types. For example, the negation operator subtracts an `unsigned short` from 2^{16} under PCC and from 2^{32} under MPW C.

Bit fields

MPW C provides bit fields that are unsigned, as do many if not all 68000 versions of PCC. However, VAX implementations of C may support signed bit fields. In the following example, implementations using unsigned bit fields will set `i` to 3; implementations using signed bit fields will set `i` to –1:

```
struct {int  field:2;}  x;
int i;

x.field  =  3;
i  =  x.field;
```

The `-x55` compiler option causes the Compiler to treat bit fields as signed rather than unsigned.

Evaluation order

MPW C does not define the evaluation order of certain expressions. Expressions with side effects, such as function calls and the ++ and -- operators, may yield different results on different machines or with different compilers. Specifically, when a variable is modified as a side effect of an expression's evaluation and the variable is also used at another point in the same expression, the value used may be either the value before modification or the value after modification.

Programs should not rely on the order of evaluation in these situations. The function call

```
f(i, i++)
```

is an example of an expression whose value is undefined.

Case statements

Some implementations of C, including PCC, allow cases of a `switch` statement to be nested within compound statements. MPW C considers this an error. The following `switch` statement compiles using PCC but generates an error message using the MPW C Compiler. The error is that `case 2:` is within the `if` statement.

```
switch (i) {
    case 1:
        if (j) {
            case 2:
                i = 3;
        }
    }
```

Language anachronisms

Several constructs formerly considered part of the C language are now considered anachronisms. When you specify the `-z84` compiler option, anachronistic constructs are compiled and flagged with a warning message. Otherwise they are considered invalid. The anachronisms involve assignment operators, initialization statements, and references to structures and unions.

Assignment operators

The `=op` form of assignment operators is not supported. Alternate interpretations are accepted without warning. In particular,

`x =-  5;`	is interpreted as	`x = (-5);`
`x =*  5;`	is interpreted as	`x = (*5);`
`x =&  p;`	is interpreted as	`x = (&p);`

Initialization

The equal sign that introduces an initializer must be present. The anachronism

```
int i 1;
```

is considered an error.

Structures and unions

References to members of structures and unions must be to the appropriate structure or union. For example, the reference `a.b` is illegal if `b` is not a member of `a`. References to components of nested structures and unions must be fully qualified (that is, all intermediate levels of the reference must be specified).

The names of structure and union members do not conflict with the names of ordinary variables in the same scope. Furthermore, a particular member name may be used in several structures and unions in the same scope.

Compiler limitations

The total size of all declared global variables, static variables, and string constants cannot exceed 32K bytes. Allocate large global arrays on the heap in order to avoid exceeding this limit.

The size of the largest function you can compile in MPW C is limited by the memory available for the Compiler's internal data structures. The problem can be reduced by eliminating unnecessary include files, reducing the number of global declarations, compiling large functions separately, and rewriting large functions as two or more smaller functions. You can also make more memory available to the Compiler by compiling without the debugger installed.

Chapter 3

The Standard C Library

About the Standard Library

This chapter describes the Standard C Library provided with MPW C. The Standard C Library (Chapter 3) is a collection of basic routines that let you read and write files, examine and manipulate strings, perform data conversion, acquire and release memory, and perform mathematical operations.

The chapter begins with an introduction to the error-number conventions used in the Standard C Library, followed by the library functions and macros arranged alphabetically by header. For example, both the `fread` and `fwrite` macros are found under the `fread` header. All of the function names and other identifiers used in Standard C Library routines are listed in Appendix C, "The Library Index."

❖ *Note:* Remember that identifiers in C are case sensitive and should be spelled exactly as shown in the synopsis.

The library routines under each header are documented as follows:

- *Synopsis* shows the code you need to add to your program when using these library routines and files you need to include at compile time.
- *Description* discusses the library routines and their input and output.
- *Diagnostics* describes error conditions.
- *Return value* describes the values returned by the routines.
- *Note* contains remarks.
- *Warning* gives cautions.
- *See also* provides the names of other library routines or sections in this chapter related to the ones described in the current document.

Error numbers

Synopsis

```
#include <ErrNo.h>

extern int errno;
extern short MacOSErr;
```

Description

Many of the Standard C Library functions have one or more possible error returns. An otherwise meaningless return value, usually −1, indicates an error condition; see descriptions of individual functions for details. The external variable `errno` also provides an error number. Variable `errno` is not cleared on successful calls, so it should be tested only if the return value indicates an error.

The error name appears in brackets following the text in a library function description; for example,

"The next attempt to write a nonzero number of bytes will signal an error. [ENOSPC]"

Not all possible error numbers are listed for each library function because many errors are possible for most of the calls. Some UNIX operating system error numbers do not apply to Macintosh and are not documented in this manual. Some calls go to the Macintosh ROM and return a value in `MacOSErr` as well as the value in `errno`.

Here is a list of the error numbers and their names as defined in the <ErrNo.h> file.

2 `ENOENT` *No such file or directory*
This error occurs when a file whose filename is specified does not exist or when one of the directories in a pathname does not exist.

3 `ENORSRC` *Resource not found*
A required resource was not found. This error applies to `faccess` calls that return tab, font, or print record information.

5 `EIO` *I/O error*
Some physical I/O error has occurred. This error may in some cases be signaled on a call following the one to which it actually applies.

6 `ENXIO` *No such device or address*
I/O on a special file refers to a subdevice that does not exist, or the I/O is beyond the limits of the device. This error may also occur when, for example, no disk is present in a drive.

7 `E2BIG` *Insufficient space for return argument*
The data to be returned is too large for the space allocated to receive it.

9 `EBADF` *Bad file number*
Either a file descriptor does not refer to an open file, or a read (or write) request is made to a file that is open only for writing (or reading).

12 ENOMEM *Not enough space*
The system ran out of memory while the library call was executing.

13 EACCES *Permission denied*
An attempt was made to access a file in a way forbidden by the protection system.

14 GFAULT *Illegal filename*
A filename or volume name was too long or otherwise illegal.

17 EEXIST *File exists*
An existing file was mentioned in an inappropriate context; for example, `open(file, O_CREAT+O_EXCL)`.

19 ENODEV *No such device*
An attempt was made to apply an inappropriate system call to a device; for example, read a write-only device.

20 ENOTDIR *Not a directory*
An object that is not a directory was specified where a directory is required; for example, in a path prefix.

21 EISDIR *Is a directory*
An attempt was made to write on a directory.

22 EINVAL *Invalid parameter*
Some invalid parameter was provided to a library function.

23 ENFILE *File table overflow*
The system's table of open files is full, so temporarily a call to open cannot be accepted.

24 EMFILE *Too many open files*
The system cannot allocate memory to record another open file.

28 ENOSPC *No space left on device*
During a write to an ordinary file, there is no free space left on the device.

29 ESPIPE *Illegal seek*
An `lseek` was issued incorrectly.

30 EROFS *Read-only file system*
An attempt to modify a file or directory was made on a device mounted for read-only access.

31 EMLINK *Too many links*
An attempt to delete an open file was made.

Note Calls that interface to the Macintosh I/O system (such as `open`, `close`, `read`, `write`, and `ioctl`) can set the external variable `MacOSErr` as well as `errno` on errors. This section documents the `errno` values. The equivalent Macintosh ROM error-return values set in `MacOSErr` are documented in the Errors manual page in Chapter 4 and in the System Error Handler chapter of *Inside Macintosh*.

abs—return integer absolute value

Synopsis

```
int abs(i)
  int    i;
```

Description

Function `abs` returns the absolute value of `i`.

Note

The absolute value of the negative integer with the largest magnitude is undefined.

See also

`floor`

atof—convert ASCII string to floating-point number

Synopsis

```
extended atof(str)
  char   *str;
```

Description

Function `atof` converts a character string pointed to by `str` to an extended-precision floating-point number. The first unrecognized character ends the conversion. Function `atof` recognizes an optional string of white-space characters (spaces or tabs), then an optional sign, then a string of digits optionally containing a decimal point, then an optional *e* or *E* followed by an optionally signed integer. If the string begins with an unrecognized character, `atof` returns a NaN.

Function `atof` recognizes "INF" as infinity and "NAN" (optionally followed by parentheses that may contain a string of digits) as a NaN, with NaN code given by the string of digits. Case is ignored in the infinity and NaN string.

Diagnostics

Function `atof` honors the floating-point exception flags—invalid operation, underflow, overflow, divide by zero, and inexact—as prescribed by SANE.

See also

`scanf`, `str2dec`, `dec2num`

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atoi—convert string to integer

Synopsis

```
int atoi(str)
  char   *str;
long atol(str)
  char   *str;
```

Description

The character string `str` is scanned up to the first nondigit character other than an optional leading minus sign (–). Leading white-space characters (spaces and tabs) are ignored.

Return value

Function `atoi` returns as an integer the decimal value represented by `str`. Function `atol` returns as a long integer the decimal value represented by `str`. On the Macintosh, these functions are equivalent because `int` and `long` are the same size.

Note

Overflow conditions are ignored.

A plus sign (+) is considered a nondigit character.

See also

`atof`, `scanf`, `strtol`

close—close a file descriptor

Synopsis

```
int close(fildes)
  int    fildes;
```

Description

Parameter `fildes` is a file descriptor obtained from an open, `creat`, dup, or `fcntl` call. Function `close` closes the file descriptor indicated by `fildes`.

Function `close` fails if `fildes` is not a valid open file descriptor. [EBADF]

Diagnostics

Upon successful completion, a value of 0 is returned. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

See also

`creat`, dup, `fcntl`, open

conv—translate characters

Synopsis

```
#include <CType.h>

int toupper(c)
  int    c;
int tolower(c)
  int    c;
int _toupper(c)
  int    c;
int _tolower(c)
  int    c;
int toascii(c)
  int    c;
```

Description

Functions `toupper` and `tolower` have as their domain the set of ASCII characters (0 through 127) and the constant `EOF` (–1). If parameter `c` to `toupper` represents a lowercase letter, the result is the corresponding uppercase letter. If parameter `c` to `tolower` represents an uppercase letter, the result is the corresponding lowercase letter. All other parameters in the domain are returned unchanged.

Macros `_toupper` and `_tolower` produce the same results as functions `toupper` and `tolower` but have restricted domains and are faster. Macro `_toupper` requires a lowercase letter as its parameter; its result is the corresponding uppercase letter. Macro `_tolower` requires an uppercase letter as its parameter; its result is the corresponding lowercase letter. Parameters outside the domain cause undefined results.

Function `toascii` converts `c` by clearing all bits that are not part of a standard ASCII character. It is used for compatibility with other systems.

Note

These routines do not support the Macintosh extended character set (with values greater than 0x7F). For values outside the stated domain, the result is undefined.

See also

`ctype`, `getc`

creat—create a new file or rewrite an existing file

Synopsis

```
int creat(filename)
  char   *filename;
```

Description

Function `creat` creates a new file or prepares to rewrite an existing file, `filename`. If the file exists, the length of its data fork is set to 0.

Function `creat(filename)` is equivalent to

```
open(filename,O_WRONLY+O_TRUNC+O_CREAT)
```

Upon successful completion, a nonnegative integer (the file descriptor) is returned and the file is open for writing. The file pointer is set to the beginning of the file. A maximum of about 30 files may be open at a given time; the actual maximum depends upon the current system environment.

Return value

Upon successful completion, a nonnegative integer (the file descriptor) is returned. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

Note

Other implementations of `creat` specify a second parameter, `mode`. This version ignores any second parameter.

See also

`close`, `open`

ctype—classify characters

Synopsis

```
#include <CType.h>

int isalpha(c)
  int c;
int isalpha(c)
  int c;
int isupper(c)
  int c;
int islower(c)
  int c;
int isdigit(c)
  int c;
int isxdigit(c)
  int c;
int isalnum(c)
  int c;
int isspace(c)
  int c;
int ispunct(c)
  int c;
int isprint(c)
  int c;
int isgraph(c)
  int c;
int iscntrl(c)
  int c;
int isascii(c)
  int c;
```

Description

These macros classify character-coded integer values by table lookup, returning nonzero for `true`, zero for `false`. Macro `isascii` is defined on all integer values; the rest are defined only where `isascii` is true and on the single non-ASCII value EOF (–1).

Macro	Returns true if
`isascii`	c is an ASCII character code lower than octal 0200.
`isalpha`	c is a letter [A–Z] or [a–z].
`isupper`	c is an uppercase letter [A–Z].
`islower`	c is a lowercase letter [a–z]
`isdigit`	c is a digit [0-9].
`isxdigit`	c is a hexadecimal digit [0-9], [A-F], or [a-f].
`isalnum`	c is alphanumeric (letter or digit).
`isspace`	c is a space, tab, return, new line, vertical tab, or form feed.

`ispunct`	`c` is a punctuation character (neither control nor alphanumeric).
`isprint`	`c` is a printing character, space (octal 040) through tilde (octal 0176).
`isgraph`	`c` is a printing character, similar to `isprint` except false for space.
`iscntrl`	`c` is a delete character (octal 0177) or an ordinary control character (less than octal 040).

Warning If `c` is not in the domain of the function, the result is undefined.

Note These macros do not support the Macintosh extended character set. For values outside the domain, the result is undefined.

dup—duplicate an open file descriptor

Synopsis

```
int dup(fildes)
  int    fildes;
```

Description

Parameter `fildes` is a file descriptor obtained from an open, `creat`, dup, or `fcntl` call. The new file descriptor returned by dup is the lowest one available.

The function call `dup(fildes)` is equivalent to

```
fcntl(fildes, F_DUPFD, 0)
```

Function dup fails if parameter `fildes` is not a valid open file descriptor. [EBADF]

Return value

Upon successful completion, a nonnegative integer (the file descriptor) is returned. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

See also

`close`, `fcntl`, `open`

ecvt—convert a floating-point number to a string

Synopsis

```
char *ecvt(value, ndigit, decpt, sign)
  extended value;
  int ndigit, *decpt, *sign;
char *fcvt(value, ndigit, decpt, sign)
  extended value;
  int ndigit, *decpt, *sign;
```

Description

Function `ecvt` converts `value` to a null-terminated string of `ndigit` digits and returns a pointer to this string as the function result. The low-order digit is rounded.

The decimal point is not included in the returned string. The position of the decimal point is indicated by `decpt`, which indirectly stores the position of the decimal point relative to the returned string. If the `int` pointed to by `decpt` is negative, the decimal point lies to the left of the returned string. For example, if the string is "`12345`" and `decpt` points to an `int` of 3, the value of the string is 123.45; if `decpt` points to –3, the value of the string is .00012345.

If the sign of the converted value is negative, the `int` pointed to by `sign` is nonzero; otherwise it is zero.

Function `fcvt` provides fixed-point output in the style of Fortran F-format output. Function `fcvt` differs from `ecvt` in its interpretation of `ndigit`:

- In `fcvt`, `ndigit` specifies the number of digits to the right of the decimal point.
- In `ecvt`, `ndigit` specifies the number of digits in the string.

Note

The string pointed to by the function result is static data whose contents are overwritten by each call. To preserve the value, copy it before calling the function again.

See also

`printf`, num2dec, `dec2str`
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exit—terminate the current application

Synopsis

```
void exit(status)
  int    status;
void _exit(status)
  int    status;
```

Description

Functions exit and _exit close open file descriptors and terminate the application or tool. Here is the order in which exit performs its duties:

1. It executes all exit procedures in reverse order of their installation by onexit, including the exit procedures for the Standard I/O package if Standard I/O routines were used. All buffered files are flushed and closed.
2. It closes all open files that were opened with open or fopen.
3. If the program is a tool running under the MPW Shell, the exit function returns status and control to the MPW Shell by placing a return value in the lower three bytes of status and terminating the application.

Function _exit circumvents the exit procedures described in step 1 above. Use _exit instead of exit to abort your program when you are uncertain about the integrity of the data space.

Return value

The main program is a function that returns an integer. The return value of main is interpreted by the MPW Shell as the program status. When you call exit or _exit, the status parameter is returned to the MPW Shell as the return value for the application's main function: 0 for normal execution or a small positive value for errors (typically 1..3). Main programs that return to the Shell without setting status to an integer value appear to be returning a random status.

There is no return from exit or _exit.

Note

Functions exit and _exit do not close files you opened with calls to the I/O routines documented in *Inside Macintosh*.

Don't call exit or _exit from a desk accessory.

See also

onexit, stdio

exp—exponential, logarithm, power, square-root functions

Synopsis

```
#include <Math.h>

extended exp(x)
  extended x;
extended log(x)
  extended x;
extended log10(x)
  extended x;
extended pow(x, y)
  extended x, y;
extended sqrt(x)
  extended x;
```

Description

Function `exp(x)` returns e^x, where e is the natural logarithm base.

Function `log(x)` returns the natural logarithm of x, $\log_e x$.

Function `log10(x)` returns the base-10 logarithm of x, $\log_{10} x$.

Function `pow(x, y)` returns x^y.

Function `sqrt(x)` returns the square root of x.

For special cases, these functions return a NaN or signed infinity as appropriate.

Diagnostics

These functions honor the floating-point exception flags—invalid operation, underflow, overflow, divide by zero, and inexact—as prescribed by SANE.

See also

`hypot`, `sinh`
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faccess—named file access and control

Synopsis

```
#include <FCntl.h>

int faccess(filename, cmd, arg)
  char   *filename;
  unsigned int cmd;
  long   *arg;
```

Description

Function `faccess` provides access to control and status information for named files. (Compare function `ioctl`, which provides different control and status information for open files.)

Parameter cmd must be set to one of the constants in the following list to indicate what operation is to be performed on the file. As noted in the list, some calls to `faccess` also require the `arg` parameter, usually as a `long` or as a pointer to a `long`.

The following commands are available to all programs:

Value of cmd	Description
F_DELETE	Deletes the named file, or returns an error if the file is open. Parameter `arg` is ignored.
F_RENAME	Renames the named file. Parameter `arg` is a pointer to a string containing the new name.

The following commands can be used only by a program running as an MPW tool:

Value of cmd	Description
F_GTABINFO	Gets the tab offset for the MPW text file `filename`. The tab offset is stored in the long integer pointed to by `arg`. The tab offset is expressed as an integer number of spaces. The width of the space character in the current font determines the actual distance of the tab offset.
F_STABINFO	Sets the tab offset for the MPW text file `filename`. The tab offset is specified as a `long` value in `arg`.
F_GFONTINFO	Gets the font number and font size for an MPW text file `filename`. The font number is stored in the high-order half of the `long` pointed to by `arg`; the font size is stored in the low-order half of the same `long`.
F_SFONTINFO	Sets the font number and font size for the MPW text file, `filename`. The font number is specified in the high-order half of `arg`; the font size is specified in the low-order half of `arg`.

`F_GPRINTREC`	Gets a print record `TPrint` for an MPW text file, `filename`; `arg` is a handle to the print record.
`F_SPRINTREC`	Sets a print record for the MPW text file `filename`; `arg` is a handle to the print record.
`F_OPEN`	Reserved for operating system use.

`F_GTABINFO` and `F_GFONTINFO` pass `arg` as a pointer to a `long`; `F_STABINFO` and `F_SFONTINFO` pass `arg` as a `long` value; and `F_GPRINTREC` and `F_SPRINTREC` pass `arg` as a handle to a print record.

Return value

Upon successful completion, `faccess` returns a nonnegative value, usually 0. If the device for the named file cannot perform the requested command, `faccess` returns –1 and `errno` is set to indicate the error.

If the requested resource for `F_GTABINFO`, `F_GFONTINFO`, or `F_GPRINTREC` does not exist for the named file, default values are stored and the function returns a value greater than 0.

Note

Before calling faccess with `F_GPRINTREC` or `F_SPRINTREC`, the Printing Manager must be initialized and the print record handle `THPrint` must be allocated. The font size must be 9, 10, 12, 14, 18, or 24; the font number must be 0 or a positive integer. The following sequence must be used with these print command values:

```
res = CurResFile();
PRClose();
UseResFile(res);
PROpen(); /* do whatever, including call faccess print commands */
PRClose();
UseResFile(res);
```

See also

`ioctl`, `unlink`

fclose—close or flush a stream

Synopsis

```
#include <StdIO.h>

int fclose(stream)
  FILE   *stream;
int fflush (stream)
  FILE   *stream;
```

Description

Function fclose closes a file that was opened by fopen, freopen, or fdopen. Function fclose causes any buffered data for stream to be written out, and the buffer (if one was allocated by the system) is released; fclose then calls close to close the file descriptor associated with stream. The value of the parameter stream cannot be used unless reassigned with fopen, fdopen, or freopen.

Function fclose fails if the file descriptor associated with stream is already closed. [ENOENT]

Function fclose is performed automatically for all open FILE streams upon calling exit.

Function fflush causes any buffered data for stream to be written out; stream remains open.

Return value

These functions return 0 for success or EOF if an error was detected (such as trying to write to a file that has not been opened for writing).

See also

close, exit, fopen, setbuf

fcntl—file control

Synopsis

```
#include <FCntl.h>

int fcntl(fildes, cmd, arg)
  int    fildes;
  unsigned int cmd;
  int    arg;
```

Description

Function `fcntl` is used for duplicating file descriptors. A file remains open until all of its file descriptors are closed.

Parameter `fildes` is an open file descriptor obtained from an `open`, `creat`, `dup`, or `fcntl` call. Parameter cmd takes the value `F_DUPFD`, which tells `fcntl` to return the lowest numbered available file descriptor greater than or equal to `arg`. Normally `arg` is greater than or equal to 3, to avoid obtaining the standard file descriptors 0, 1, and 2. Function `fcntl` returns a new file descriptor that points to the same open file as `fildes`. The new file descriptor has the same access mode (read, write, or read/write) and file pointer as `fildes`. Any I/O operation changes the file pointer for all file descriptors that share it.

Function `fcntl` fails if one or more of the following are true:

- Parameter `fildes` is not a valid open file descriptor. [`EBADF`]
- Parameter `arg` is negative or greater than the highest allowable file descriptor. [`EINVAL`]

Return value

Upon successful completion, the value returned is a new file descriptor. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

Note

The `F_GETFD`, `F_SETFD`, `F_GETFL`, and `F_SETFL` commands of `fcntl` are not supported on the Macintosh.

See also

`close`, `dup`, `open`

ferror—stream status inquiries

Synopsis

```
#include <StdIO.h>

int feof(stream)
  FILE   *stream;
int ferror(stream)
  FILE   *stream;
void clearerr(stream)
  FILE   *stream;
int fileno(stream)
  FILE   *stream;
```

Description

Macro `feof` returns nonzero when end of file has previously been detected reading the named input stream; otherwise, it returns zero.

Macro `ferror` returns nonzero when an I/O error has previously occurred reading from or writing to the named stream; otherwise, it returns zero.

Macro `clearerr` resets the error indicator and end-of-file indicator to zero on the named stream.

Macro `fileno` returns the integer file descriptor associated with the named stream; see open.

See also

open, `fopen`

floor—floor, ceiling, mod, absolute value functions

Synopsis

```
#include <Math.h>

extended floor(x)
  extended x;
extended ceil(x)
  extended x;
extended fmod(x, y)
  extended x, y;
extended fabs(x)
  extended x;
```

Description

Function `floor(x)` returns the largest integer (as an extended-precision number) not greater than x.

Function `ceil(x)` returns the smallest integer not less than x.

Whenever possible, `fmod(x, y)` returns the number f with the same sign as x, such that $x = i\,y + f$ for some integer i, and $|f| < |y|$. If y is 0, fmod returns a NaN.

Function `fabs(x)` returns $|x|$, the absolute value of x.

See also

`abs`, `rint`, `setround`

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fopen—open a buffered file stream

Synopsis

```
#include <StdIO.h>

FILE *fopen(filename, type)
  char   *filename, *type;
FILE *freopen(filename, type, stream)
  char   *filename, *type;
  FILE   *stream;
FILE *fdopen(fildes, type)
  int    fildes;
  char   *type;
```

Description

Function `fopen` opens the file named by `filename` and associates a stream with it. Function `fopen` returns a pointer to the `FILE` structure associated with the stream.

Parameter `filename` points to a character string that contains the name of the file to be opened.

The value of `type` should be one of the values in the first column in the following table. The headings "Open Mode Used" and "Description" explain how type is used. For more information, see `open`.

Value	Open mode used	Description
r	O_RDONLY	Open for reading only.
w	O_WRONLY+O_CREAT+O_TRUNC	Truncate or create for writing.
a	O_WRONLY+O_APPEND	Append: open for writing at end of file, or create for writing.
r+	O_RDWR	Open for update (reading and writing).
w+	O_RDWR+O_CREAT+O_TRUNC	Truncate or create for update.
a+	O_RDWR+O_CREAT+O_APPEND	Append: open or create for update at end of file.

Function `freopen` substitutes the named file for the open stream. The original stream is closed, regardless of whether the open ultimately succeeds. Function `freopen` returns a pointer to the `FILE` structure associated with `stream`. Function `freopen` is typically used to attach the previously opened streams associated with `stdin`, `stdout`, and `stderr` to other files.

Function `fdopen` associates a stream with a file descriptor by formatting a file structure from the file descriptor. Thus, `fdopen` can be used to access the file descriptors returned by `open`, `creat`, `dup`, or `fcntl`. (These calls return file descriptors, not pointers to a `FILE` structure.) The type of stream must agree with the mode of the open file.

When a file is opened for update, both input and output may be done on the resulting stream. However, output may not be directly followed by input without an intervening `fseek` or `rewind`, and input may not be directly followed by output without an intervening `fseek`, `rewind`, or an input operation that encounters end of file.

When a file is opened for append (that is, when `type` is `a` or `a+`), it is impossible to overwrite information already in the file. Function `fseek` may be used to reposition the file pointer to any position in the file, but when output is written to the file the current file pointer is disregarded. All output is written at the end of the file and causes the file pointer to be repositioned at the end of the output.

Return values On success, functions `fopen`, `freopen`, and `fdopen` return a valid file pointer. On failure, `NULL` is returned.

The maximum number of open `FILE` streams is 20.

Note The parameter type must have one of the values in the first column in the table; do not use values intended for open, such as `O_RDONLY`.

See also `open`, `fclose`, `fseek`

fread—binary input/output

Synopsis

```
#include <StdIO.h>

int fread(ptr, size, nitems, stream)
  char   *ptr;
  int    size, nitems;
  FILE   *stream;
int fwrite(ptr, size, nitems, stream)
  char   *ptr;
  int    size, nitems;
  FILE   *stream;
```

Description

Function fread copies nitems items of data from the named input stream into an array beginning at ptr. An item of data is a sequence of size bytes (not necessarily terminated by a null byte). Function fread stops appending bytes if an end of file or error condition is encountered while reading stream or if nitems items have been read. Function fread leaves the file pointer in stream pointing to the byte following the last byte read.

Function fwrite writes at most nitems items of data to the named output stream from the array pointed to by ptr. An item is a sequence of size bytes. Function fwrite stops writing when it has written nitems items of data or if an error condition is encountered on stream. Function fwrite does not change the contents of the array pointed to by ptr.

The parameter size is typically

```
sizeof(*ptr)
```

where sizeof specifies the length of an item pointed to by ptr. If ptr points to a data type other than char, it should be cast into a pointer to char.

Return values

Functions fread and fwrite return the number of items read or written. If nitems is 0 or negative, no characters are read or written and 0 is returned by both fread and fwrite.

See also

fopen, getc, gets, printf, putc, puts, read, scanf, stdio, write

frexp—manipulate parts of floating-point numbers

Synopsis

```
extended frexp(value, eptr)
  extended value;
  int    *eptr;
extended ldexp(value, exp)
  extended value;
  int    exp;
extended modf(value, iptr)
  extended value, *iptr;
```

Description

Every nonzero number can be written uniquely as $x * 2^n$, where the mantissa (fraction) x is in the range $0.5 \le |x| < 1.0$ and the exponent n is an integer. Function `frexp` returns the mantissa of an `extended` value and stores the exponent indirectly in the location pointed to by `eptr`. Note that the mantissa here differs from the significand described in the *Apple Numerics Manual,* whose normal values are in the range $1.0 \le |x| < 2.0$.

Function `ldexp` returns the quantity $value * 2^{exp}$.

Function `modf` returns the signed fractional part of `value` and stores the integral part indirectly in the location pointed to by `iptr`.

Diagnostics

Function `ldexp` honors the floating-point exception flags—invalid operation, underflow, overflow, divide by zero, and inexact—as prescribed by SANE.

See also

`logb`, `scalb`

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fseek—reposition a file pointer in a stream

Synopsis

```
#include <StdIO.h>

int fseek(stream, offset, ptrname)
  FILE   *stream;
  long   offset;
  int    ptrname;
void rewind(stream)
  FILE   *stream;
long ftell(stream)
  FILE   *stream;
```

Description

Function `fseek` sets the position of the next input or output operation on the stream. The new position is `offset` bytes from the beginning, the current position, or the end of the file, when the value of `ptrname` is 0, 1, or 2, respectively. If `ptrname` is 1 or 2, offset may be negative.

The call

```
rewind(stream)
```

is equivalent to

```
fseek(stream, 0L, 0)
```

except that no value is returned.

Functions `fseek` and `rewind` undo any effects of `ungetc`.

After `fseek` or `rewind`, the next operation on a file opened for update may be either input or output.

Function `ftell` returns the offset of the current byte relative to the beginning of the file associated with the named stream.

Diagnostics

Function `fseek` returns nonzero for improper seeks; otherwise it returns zero. An example of an improper seek is an `fseek` before the beginning of, or past the end of, the file.

See also

`lseek`, `fopen`, `ungetc`

getc—get a character or a word from a stream

Synopsis

```
#include <StdIO.h>

int getc(stream)
  FILE   *stream;
int getchar()
int fgetc(stream)
  FILE   *stream;
int getw(stream)
  FILE   *stream;
```

Description

Macro `getc` returns the next character from the named input stream. It also moves the file pointer, if defined, ahead one character in `stream`. Macro `getc` cannot be used if a function is necessary; for example, you cannot have a function pointer point to it. Macro `getc` returns the integer `EOF` on end of file or error.

Macro `getchar` returns the next character from the standard input stream, `stdin`.

Function `fgetc` produces the same result as macro `getc`; function `fgetc` runs more slowly than macro `getc` but takes less space per invocation. You can also have a pointer to `fgetc` but not to `getc`.

Function `getw` returns the next `int` (that is, four bytes) from the named input stream so that the order of bytes in the stream corresponds to the order of bytes in memory. Function `getw` returns the constant `EOF` upon end of file or error. Because `EOF` is a valid integer value, `feof` and `ferror` should be used to check the success of `getw`. Function `getw` increments the associated file pointer, if defined, to point to the next `int`. Function `getw` assumes no special alignment in the file.

Return values

These calls return data from the stream, or the integer constant `EOF` (–1) at end of file or upon an error.

Note

Because it is implemented as a macro, `getc` treats a stream parameter with side effects incorrectly. In particular,

```
getc(*f++)
```

doesn't work as you would expect. Instead use

```
fgetc(*f++)
```

See also

`ferror`, `fopen`, `fread`, `gets`, `scanf`, `stdio`

getenv—access exported MPW Shell variables

Synopsis

```
char *getenv(varname)
  char   *varname;
```

Description

The **environment** is the set of exported variables provided by the MPW Shell. Function `getenv` provides access to variables in this set. (See the Variables section in Chapter 3 of the *Macintosh Programmer's Workshop Reference* for the list of standard exported Shell variables.)

Function `getenv` searches the environment for a Shell variable with the name specified by `varname` and returns a pointer to the character string containing its value. The null pointer is returned if the Shell variable is not defined or has not been exported. The Shell-variable name search is case insensitive.

Return value

Upon successful completion, a pointer to the value of `varname` is returned. If the Shell variable is not defined or not exported, the function returns the null pointer.

For standalone applications, which do not run under the MPW Shell, `getenv` always returns the null pointer.

Note

The environment can also be accessed by means of a parameter to the C main-entry-point function `main` if the main procedure is declared as

```
main(argc, arv, envp)
```

The `envp` array represents the set of MPW Shell variables that have been made available to tools by means of the MPW Export command. The `i`th `envp` entry has the form

```
envp[i] = "varname\0varvalue\0";
```

The last `envp` entry is the null pointer.

If you use `envp` to search the environment, be sure to use case-insensitive string comparisons.

Warning

Function `getenv` returns a pointer to the place in memory where a copy of the MPW Shell variable resides. Do not modify the value of a Shell variable in such a way as to increase its length.

gets—get a string from a stream

Synopsis

```
#include <StdIO.h>

char *gets(str)
  char   *str;
char *fgets(str, maxlen, stream)
  char   *str;
  int maxlen;
  FILE   *stream;
```

Description

Function `gets` reads characters from the standard input stream `stdin` into the array pointed to by `str` until a newline character is read or an end-of-file condition is encountered. The newline character is discarded, and the string is terminated with a null (`\0`) character. (For more information about newline, see "The Newline, Carriage-Return, and Vertical-Tab Characters" in Chapter 2.)

Function `fgets` reads characters from `stream` into the array pointed to by `str` until `maxlen`–1 characters are read, a newline character is read and transferred to `str`, or an end-of-file condition is encountered. The string is then terminated with a null character.

Return values

If end of file is encountered and no characters have been read, no characters are transferred to `str` and `NULL` is returned. If a read error occurs, `NULL` is returned. Otherwise `str` is returned. (A read error will occur, for example, if you attempt to use these functions on a file that has not been opened for reading.)

Note

The array pointed to by `str` is assumed to be large enough; overflow is not checked.

The function `gets` omits the newline character in the string; `fgets` leaves it in.

See also

`ferror`, `fopen`, `fread`, `getc`, `scanf`, `stdio`

hypot—Euclidean distance function

Synopsis

```
#include <Math.h>

extended hypot(x, y)
  extended x, y;
```

Description

Function `hypot` returns

```
sqrt (x * x + y * y)
```

taking precautions against unwarranted overflows.

Diagnostics

Function `hypot` honors the floating-point exception flags—invalid operation, underflow, overflow, divide by zero, and inexact—as prescribed by SANE.

See also

`exp`
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ioctl—control a device

Synopsis

```
#include <IOCtl.h>

int ioctl(fildes, cmd, arg)
  int    fildes;
  unsigned int cmd;
  long   *arg;
```

Description

Function `ioctl` communicates with a file's device handler by sending control information, requesting status information, or both. Parameter cmd indicates which device-specific operations `ioctl` must perform. Here are the control values:

Value of cmd	Description
FIOINTERACTIVE	Function `ioctl` returns 0 if the device is interactive; if not, it returns –1 and `errno` is set to `EINVAL`. Parameter `arg` is ignored.
FIOBUFSIZE	Function `ioctl` returns, in bytes, the optimal buffer size for this device; the buffer size is returned in a `long` pointed to by `arg`. If the device has no default buffer size, `ioctl` returns –1 and `errno` is set to `EINVAL`.
FIOFNAME	Function `ioctl` stores the filename associated with `fildes` in a character array 256 characters in size pointed to by `arg`. It returns –1 if the filename exceeds 255 characters [`E2BIG`].
FIOREFNUM	Function `ioctl` returns the Macintosh file reference number associated with `fildes`; the reference number is returned in the `short` pointed to by `arg`. If the `fildes` is not open on a Macintosh file (such as the console device), `ioctl` returns –1.
FIOSETEOF	Function `ioctl` sets the logical end of file specified in the `long` parameter `arg`. The value of `arg` is the new size of the file, in bytes. This command can be used to reduce or increase the size of the open file. The current file pointer is not affected unless the file size is set below it.
TIOFLUSH	Used only for the console device and other terminal devices. Function `ioctl` returns –1 if `fildes` is not a terminal device. `TIOFLUSH` tells the device handler to throw away unread terminal input. Parameter `arg` is ignored.

The following two functions are used only for the console device when running standalone:

`TIOGPORT`	Function `ioctl` returns the console GrafPort in a `GrafPtr` pointed to by `arg`.
`TIOSPORT`	Function `ioctl` sets the console GrafPort to the value specified by the `GrafPtr arg`. Subsequent writes to the console will display on this GrafPort.

Function `ioctl` fails if one or both of the following conditions exist:

- □ File descriptor `fildes` is not valid or is not open. [EBADF]
- □ Parameters cmd or `arg` are not valid for the device handler associated with `fildes`. [EINVAL]

Diagnostics

If an error has occurred, a value of –1 is returned and `errno` is set to indicate the error.

Note

For cmd values `FIOINTERACTIVE` and `FIOBUFSIZE`, a function return of –1 is a meaningful response, not an error. For `FIOINTERACTIVE`, `errno` is set to `EINVAL` for devices that are not interactive. For `FIOBUFSIZE`, `errno` is set to `EINVAL` for devices that have no default buffering.

The cmd values `FIOLSEEK` and `FIODUPFD` are reserved for operating system use.

If you set the console GrafPort with `TIOSPORT`, do not deallocate the storage for that port; the console device is written to by the `exit` function as your application terminates.

Warning

`FIOREFNUM` lets you do Macintosh I/O operations such as `Allocate` that are not available through `ioctl`. Do not close or modify the file pointer using the reference number.

See also

`fcntl`

lseek—move read/write file pointer

Synopsis

```
long lseek(fildes, offset, whence)
  int    fildes;
  long   offset;
  int    whence;
```

Description

A file descriptor, `fildes`, is returned from a call to `creat`, dup, `fcntl`, or open. Function `lseek` sets the file pointer associated with `fildes` as follows:

- □ If whence is 0, the pointer is set to `offset` bytes.
- □ If whence is 1, the pointer is set to its current location plus `offset`.
- □ If whence is 2, the pointer is set to the size of the file plus `offset`.
- □ If whence is 1 or 2, the value of `offset` may be negative.

Upon successful completion, the file pointer value as measured in bytes from the beginning of the file is returned.

The file pointer remains unchanged and `lseek` fails if one or more of the following are true:

- □ File descriptor `fildes` is not open. [EBADF]
- □ Parameter whence is not 0, 1, or 2. [EINVAL]
- □ The resulting file pointer would point past end of file. [ESPIPE]
- □ The resulting file pointer would point before beginning of file. [EINVAL]

Some devices are incapable of seeking. The value of the file pointer associated with such a device is undefined.

Return value

Upon successful completion, a nonnegative long integer indicating the file-pointer value is returned. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

Note

In previous versions of the Standard C Library, `tell(fildes)` was a function that returned the current file position. It is equivalent to the call

```
lseek(fildes, 0L, 1)
```

Warning

Function `lseek` has no effect on a file opened with the O_APPEND flag because the next write to the file always repositions the file pointer to the end before writing."

See also

`fseek`, `open`

malloc—memory allocator

Synopsis

```
char *malloc(size)
  unsigned int size;
void free(ptr)
  char   *ptr;
char *realloc(ptr, size)
  char   *ptr;
  unsigned int size;
char *calloc(nelem, elsize)
  unsigned int nelem, elsize;
void cfree(ptr, nelem, elsize)
  char *ptr;
  unsigned int nelem, elsize;
```

Description

Functions `malloc` and `free` provide a simple general-purpose memory allocation package. The storage area expands as necessory when `malloc` is called.

Function `malloc` allocates the first sufficiently large contiguous free space it finds and returns a pointer to a block of at least `size` bytes suitably aligned for any use. It calls `NewPtr` (see *Inside Macintosh*) to get more memory from the system when there is no suitable space already free.

Function `free` takes a parameter that is a pointer to a block previously allocated by `malloc`. If its size is greater than 2K bytes, it is returned to the system using `DisposePtr`. Blocks smaller than that are cached by `malloc` for further allocation by `malloc` only. Undefined results occur if the space assigned by `malloc` is overrun or if a random value is passed to `free`.

Function `realloc` changes the size of the block pointed to by `ptr` to `size` bytes and returns a pointer to the (possibly moved) block. The contents are unchanged up to the lesser of the new and old sizes. If no free block of `size` bytes is available in the storage area, `realloc` asks `malloc` to enlarge the storage area by `size` bytes and then moves the data to the new space. If `ptr` is `NULL`, `realloc` is equivalent to `malloc`.

Function `calloc` allocates space for an array of `nelem` elements of size `elsize`. The space is initialized to zeros.

Function `cfree`, like `free`, frees memory allocated by `calloc`; `cfree` is included for compatibility with other systems. Parameters `nelems` and `elsize` are ignored.

Diagnostics

Functions `malloc`, `realloc`, and `calloc` return a null pointer if there is no available memory or if the storage area has been detectably corrupted by storing outside the bounds of a block. When this happens, the block pointed to by `ptr` may have been destroyed.

memory—memory operations

Synopsis

```
char *memccpy(dest, source, c, n)
  char   *dest, *source;
  int    c, n;
char *memchr(source, c, n)
  char   *source;
  int    c, n;
int memcmp(a, b, n)
  char   *a, *b;
  int    n;
char *memcpy(dest, source, n)
  char   *dest, *source;
  int    n;
char *memset(dest, c, n)
  char   *dest;
  char   c;
  int    n;
```

Description

These functions operate efficiently on memory areas (arrays of characters bounded by a count, not terminated by a null character). They do not check for the overflow of any receiving memory area.

Function memccpy copies characters from memory area source into dest, stopping after the first occurrence of character c has been copied or after n characters have been copied, whichever comes first. It returns either a pointer to the character after the copy of c in dest or a null pointer if c was not found in the first n characters of source.

Function memchr returns either a pointer to the first occurrence of character c in the first n characters of memory area source or a null pointer if c does not occur.

Function memcmp compares its parameters, a and b, looking at the first n characters only. It returns an integer less than, equal to, or greater than 0, depending on whether a is less than, equal to, or greater than b in the ASCII collating sequence.

Function memcpy copies n characters from memory area source to dest. It returns dest.

Function memset sets the first n characters in memory area dest to the value of character c. It returns dest.

Warning

Overlapping moves yield unexpected results.

Function memcmp uses signed arithmetic when comparing its parameters. The sign of the result will be incorrect for characters with values greater than 0x7F in the Macintosh extended character set.

See also `BlockMove`, `string`

onexit—install a function to be executed at program termination

Synopsis

```
int onexit(func);
  void (*func)();
```

Description

Function `onexit` installs the `exit` function pointed to by `func` by adding it to a list. The list is initially empty. A list entry is added whenever `onexit` is called. Function `exit` calls the functions in the list in the reverse order in which they were added. To ensure that buffers are flushed at program termination, the Standard I/O package adds its cleanup function to the list the first time it allocates a buffer. Each function in the list is called without parameters either at program termination or when `exit` is called.

The number of user-supplied exit functions is limited to seven.

Diagnostics

The function returns a nonzero value if the installation succeeds.

Note

A call to `_exit` circumvents user exit procedures installed by `onexit`.

Warning

If a function is installed more than once, the behavior is undefined.

See also

`exit`, `stdio`

open—open for reading or writing

Synopsis

```
#include <FCntl.h>
int open(filename, oflag)
  char   *filename;
  int    oflag;
```

Description

Parameter `filename` is a disk file, window, selection, or pseudofile. (See the section "Pseudo-Filenames" in Chapter 3 of the *Macintosh Programmer's Workshop Reference* for more information.) Function open opens a file descriptor for the named file and sets the file-status flags according to the value of `oflag`. The value of `oflag` is constructed by OR-ing flag settings; for example,

```
fildes = open("MyFile", O_WRONLY|O_CREAT|O_TRUNC);
```

To construct `oflag`, first select one of the following access modes:

□ `O_RDONLY`	Open for reading only.
□ `O_WRONLY`	Open for writing only.
□ `O_RDWR`	Open for reading and writing.

Then optionally add one or more of these modifiers:

□ `O_APPEND`	The file pointer is set to the end of the file before each write.
□ `O_CREAT`	If the file does not exist, it is created.
□ `O_TRUNC`	If the file exists, its length is truncated to 0; the mode and owner are unchanged.
□ `O_RSRC`	The file's resource fork is opened. (Normally, the data fork is opened.)

The following setting is valid only if `O_CREAT` is also specified:

□ `O_EXCL`	Function open fails if the file exists.

Upon successful completion, a nonnegative integer (the file descriptor) is returned. The file pointer used to mark the current position within the file is set to the beginning of the file.

The named file is opened unless one or more of the following are true:

- □ `O_CREAT` is not set and the named file does not exist. [`ENOENT`]
- □ More than about 30 file descriptors are currently open. The actual limit varies according to runtime conditions. [`EMFILE`]
- □ `O_CREAT` and `O_EXCL` are set and the named file exists. [`EEXIST`]

Return value

Upon successful completion, a nonnegative integer (the file descriptor) is returned. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

See also `close`, `creat`, `lseek`, `read`, `write`

printf—print formatted output

Synopsis

```
#include <StdIO.h>

int printf(format [ , arg ] ... )
  char   *format;
int fprintf(stream, format [ , arg ] ... )
  FILE   *stream;
  char   *format;
int sprintf(str, format [ , arg ] ... )
  char   *str, format;
```

Description

Function `printf` places formatted output on the standard output stream `stdout`. Function `fprintf` places formatted output on the named output stream `stream`. Function `sprintf` places formatted output, followed by the null character (`\0`), into the character array pointed to by `str`; it's your responsibility to ensure that enough room is available. Each function returns the number of characters transmitted (not including the `\0` in the case of `sprintf`), or a negative value if an output error was encountered.

Each of these functions converts, formats, and prints its `arg` parameters under control of the `format` parameter. The format is a character string that contains two types of objects: plain characters, which are simply copied to the output stream, and conversion specifications, each of which results in fetching zero or more `arg` parameters. The behavior of the function is undefined if there are insufficient `arg` parameters for the format. If the format is exhausted while `arg` parameters remain, the extra `arg` parameters are ignored.

Each conversion specification is introduced by the character `%`. After `%`, the following appear in sequence:

1. Zero or more flag characters, which modify the meaning of the conversion specification.
2. An optional decimal digit string specifying a minimum field width. If the converted value has fewer characters than the field width, it will be padded to the field width on the left (default) or right (if the left-adjustment flag has been given); see below for flag specification.
3. A precision that gives the minimum number of digits to appear for the `d`, `o`, `u`, `x`, or `X` conversions; the number of digits to appear after the decimal point for the `e`, `E`, and `f` conversions; the maximum number of significant digits for the `g` and `G` conversions; or the maximum number of characters to be printed from a string in the `s` conversion. The format of the precision is a period (`.`) followed by a decimal digit string; a null digit string is treated as zero.

4. An optional `l` specifying that a following `d`, `o`, `u`, `x`, or `X` conversion character applies to an `arg` parameter of type `long`. The `l` option is ignored in this implementation because type `int` and type `long` both require 32 bits.
5. A character that indicates the type of conversion to be applied.

A field width or precision may be indicated by an asterisk (*) instead of a digit string. In this case, an integer `arg` parameter supplies the field width or precision. The `arg` parameter that is actually converted is not fetched until the conversion letter is seen; therefore, the `arg` parameters specifying field width or precision must appear immediately before the `arg` parameter (if any) to be converted.

These are the flag characters and their meanings:

–	The result of the conversion will be left justified within the field.
+	The result of a signed conversion always begins with a sign (+ or –).
`blank`	If the first character of a signed conversion is not a sign, a space will be prefixed to the result. This implies that if the `blank` and + flags both appear, the `blank` flag will be ignored.
#	The value is to be converted to an alternate form. For `c`, `d`, `s`, and `u` conversions, the flag has no effect. For `o` conversion, it increases the precision to force the first digit of the result to be a zero. For `x` (`X`) conversion, a nonzero result will have `0x` (`0X`) prefixed to it. For `e`, `E`, `f`, `g`, and `G` conversions, the result will always contain a decimal point, even if no digits follow the point. (Normally, a decimal point appears in the result of these conversions only if a digit follows it.) For `g` and `G` conversions, trailing zeros in the fractional part will not be removed from the result (as they normally are).

The conversion characters and their meanings are these:

`d`, `o`, `u`, `x`, `X`	The integer `arg` parameter is converted to signed decimal (`d`), unsigned octal (`o`), unsigned decimal (`u`), or unsigned hexadecimal notation (`x` and `X`), respectively; the letters `abcdef` are used for `x` conversion and the letters `ABCDEF` for `X` conversion. The precision specifies the minimum number of digits to appear; if the value being converted can be represented in fewer digits, it will be expanded with leading zeros. The default precision is 1. The result of converting a zero value with a precision of zero is a null string.

`f`	The `float`, `double`, `comp`, or `extended` `arg` parameter is converted to decimal notation in the form "[-]*ddd*.*ddd*", where the number of digits after the decimal point is equal to the precision specification. If the precision is missing, it is assumed to be 6; if the precision is explicitly 0, no decimal point appears. Infinities are printed in the form "[-]INF", and NaNs are printed in the form "[-]NAN(*ddd*)", where *ddd* is a code indicating why the result is not a number.
`e`, `E`	The `float`, `double`, `comp`, or `extended` `arg` parameter is converted in the form "[-]d.*ddd*e±*dd*", where there is one digit before the decimal point and the number of digits after it is equal to the precision. When the precision is missing, it is assumed to be 6; if the precision is 0, no decimal point appears. The `E` format code produces a number with `E` instead of `e` introducing the exponent. The exponent always contains at least two digits. Infinities arc printed as `INF` and NaNs are printed in the form "[-]NAN(*ddd*)", where *ddd* is a code indicating why the result is not a number.
`g`, `G`	The `float`, `double`, `comp`, or `extended` `arg` parameter is printed in style `f` or `e` (or in style `f` or `E` in the case of a `G` format code), with the precision specifying the number of significant digits. The style used depends on the value converted: style `e` is used only if the exponent resulting from the conversion is less than –4 or greater than the precision. Trailing zeros are removed from the result. A decimal point appears only if it is followed by a digit.
`c`	The character `arg` parameter is printed.
`s`	The `arg` parameter is taken to be a string (character pointer) and characters from the string are printed until a null character (`\0`) is encountered or the number of characters indicated by the precision specification is reached. If the precision is missing, it is taken to be infinite, so all characters up to the first null character are printed. If the string pointer `arg` parameter has the value zero, the result is undefined; a zero `arg` parameter yields undefined results.
`%`	Print a `%`; no parameter is converted.

In no case does a nonexistent or small field width cause truncation of a field. If the result of a conversion is wider than the field width, the field is simply expanded to contain the conversion result. Characters generated by `printf` and `fprintf` are printed as if `putc` had been called.

Examples

To print a date and time in the form "Sunday, July 3, 10:02", where weekday and month are pointers to null-terminated strings:

```
printf("%s, %s %d, %.2d:%.2d", weekday, month, day, hour, min);
```

To print pi to five decimal places:

```
printf("pi = %.5f", pi());
```

Note Calling `sprintf` causes other Standard I/O functions to be loaded, even though `sprintf` doesn't perform any I/O.

See also `dec2str`, `ecvt`, `num2dec`, `putc`, `scanf`, `stdio`

putc—put character or word on a stream

Synopsis

```
#include <StdIO.h>

int putc(c, stream)
  char   c;
  FILE   *stream;
int putchar(c)
  char   c;
int fputc(c, stream)
  char   c;
  FILE   *stream;
int putw(w, stream)
  int    w;
  FILE   *stream;
```

Description

Macro `putc` writes the character `c` to the output stream at the current position of the file pointer. Macro `putchar(c)` is equivalent to

```
putc(c, stdout)
```

Function `fputc` behaves like macro `putc`. Function `fputc` runs more slowly than macro `putc` but takes less space per invocation.

Function `putw` writes an `int` (that is, four bytes) to the output stream at the current position of the file pointer. This function neither assumes nor causes special alignment in the file.

For information about buffering of output files, see the `stdio` page.

Return values

On success, these functions each return the value they have written. On failure, they return the constant `EOF`. This occurs if the file stream is not open for writing or if the output file cannot be grown. Because `EOF` is a valid integer, `ferror` should be used to detect `putw` errors.

Note

Because it is implemented as a macro, `putc` treats a stream parameter with side effects incorrectly. In particular,

```
putc(c, *f++)
```

produces unexpected results. Instead use

```
fputc(c, *f++)
```

See also

`fclose`, `ferror`, `fopen`, `fread`, `getc`, `printf`, `puts`, `setbuf`, `stdio`

puts—write a string to a stream

Synopsis

```
#include <StdIO.h>

int puts(str)
  char   *str;
int fputs(str, stream)
  char   *str;
  FILE   *stream;
```

Description

Function `puts` writes the null-terminated string pointed to by `str`, followed by a newline character, to the standard output stream `stdout`.

Function `fputs` writes the null-terminated string pointed to by `str` to the named output stream `stream`.

Neither function writes the terminating null character.

Return value

Both routines return the number of characters written, or an `EOF` if there is a write error.

Note

Function `puts` appends a newline character, while `fputs` does not.

See also

`ferror`, `fopen`, `fread`, `printf`, `putc`, `stdio`

qsort—quicker sort

Synopsis

```
void qsort(base, nelem, elsize, compar)
  char   *base;
  unsigned int nelem, elsize;
int (*compar)();
```

Description

Function `qsort` is an implementation of the quicker-sort algorithm. It sorts a table of data in place.

Parameter `base` points to the element at the base of the table. Parameter `nelem` is the number of elements in the table. Parameter `elsize` is the size of an element in the table; it can be specified as `sizeof(*base)`.

Parameter `compar` is a pointer to a comparison function that you supply. Function `qsort` calls your comparison function with pointers to two elements being compared. Here is a sample declaration for your comparison function:

```
int myCompare(elem1, elem2)
      char *elem1, *elem2;
```

Your comparison function supplies the result of the comparison to `qsort` by returning one of the following integer values:

Result	Meaning
<0	The first parameter is less than the second parameter.
0	The first parameter is equal to the second parameter.
>0	The first parameter is greater than the second parameter.

Note

Parameter `base`, the pointer to the base of the table, should be of type pointer-to-element and cast to `(char *)`.

rand—a simple random-number generator

Synopsis

```
int rand()
void srand(seed)
  unsigned seed;
```

Description

Function `rand` uses a multiplicative congruential random-number generator with period 2^{32} that returns successive pseudorandom numbers in the range from 0 to $2^{15}-1$.

Function `srand` can be called at any time to reset the random-number generator to a specific seed. The generator is initially seeded with a value of 1. Identical seeds produce identical sequences of pseudorandom numbers.

See also

`Random`, `randomx`

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read—read from file

Synopsis

```
int read(fildes, buf, nbyte)
  int    fildes;
  char   *buf;
  unsigned nbyte;
```

Description

File descriptor `fildes` is obtained from a call to `open`, `creat`, `dup`, or `fcntl`.

Function `read` transfers up to `nbyte` bytes from the file associated with `fildes` into the buffer pointed to by `buf`.

On devices capable of seeking, `read` starts reading at the current position of the file pointer associated with `fildes`. Upon return from `read`, the file pointer is incremented by the number of bytes actually read.

Nonseeking devices always read from the current position. The value of a file pointer associated with such a file is undefined.

Upon successful completion, `read` returns the number of bytes actually read and placed in the buffer; this number may be less than `nbyte` if the file is associated with a window or if the number of bytes left in the file is less than `nbyte` bytes. A value of 0 is returned when an end of file has been reached, or –1 if a read error occurred.

Function read fails if `fildes` is not a valid file descriptor open for reading. [EBADF]

File descriptor 0 is opened by the MPW Shell as the standard input.

Return value

Upon successful completion, a nonnegative integer is returned indicating the number of bytes actually read. Otherwise, –1 is returned and `errno` is set to indicate the error.

See also

`creat`, `open`

scanf—convert formatted input

Synopsis

```
#include <StdIO.h>

int scanf(format [ , pointer ] ... )
  char   *format;
int fscanf(stream, format [ , pointer ] ... )
  FILE   *stream;
  char   *format;
int sscanf(str, format [ , pointer ] ... )
  char   *str, *format;
```

Description

Function `scanf` reads characters from the standard input stream `stdin`. Function `fscanf` reads characters from the named input stream `stream`. Function `sscanf` reads characters from the character string `str`. Each function converts the input according to a control string (`format`) and stores the results according to a set of `pointer` parameters that indicate where the converted output should be stored.

Parameter `format`, the control string, contains specifications that control the interpretation of input sequences. The format consists of characters to be matched in the input stream and/or conversion specifications that start with the character `%`. The control string may contain

- White-space characters (spaces and tabs) that cause input to be read up to the next non-white-space character, except as described below.
- A character (any except `%`) that must match the next character of the input stream. To match a `%` character in the input stream, use `%%`.
- Conversion specifications beginning with the character `%` and followed by an optional assignment suppression character `*`, an optional numeric maximum field width, an optional `l`, `m`, `n`, or `h` indicating the size of the receiving parameter, and a conversion code.

An input field is defined relative to its conversion specification. The input field ends when the first character inappropriate for conversion is encountered or when the specified field width is exhausted. After conversion, the input pointer points to the inappropriate character.

A conversion specification directs the conversion of the next input field; the result is placed in the variable pointed to by the corresponding parameter, which is a pointer to a basic C type such as `int` or `float`.

Assignment can be suppressed by preceding a format character with the character `*`. *Assignment suppression* means an input field is skipped; the field is read and converted but not assigned. Therefore, `pointer` should be omitted when assignment of the corresponding input field is suppressed.

The *format character* dictates the interpretation of the input field. The following format characters are legal in a conversion specification, after %:

%	A single % is expected in the input at this point; no assignment is done.
d	A decimal integer is expected; the corresponding parameter should be an integer pointer.
u	An unsigned decimal integer is expected; the corresponding parameter should be an unsigned integer pointer.
o	An octal integer is expected; the corresponding parameter should be an integer pointer.
x	A hexadecimal integer is expected; the corresponding parameter should be an integer pointer.
	The conversion characters d, u, o, and x may be preceded by l or h to indicate that a pointer to long or short, rather than int, is in the parameter list. The l is ignored in this implementation because int and long are both 32 bits.
e, f, g	A floating-point number is expected; the next field is converted accordingly and stored through the corresponding parameter, which should be a pointer to a float, double, comp, or extended, depending on the size specification. The input format for floating-point numbers is an optionally signed string of digits, possibly containing a decimal point, followed by an optional exponent field consisting of E or e followed by an optionally signed integer. In addition, infinity is represented by the string "INF", and NaNs are represented by the string "NAN", optionally followed by parentheses that may contain a string of digits (the NaN code). Case is ignored in the infinity and NaN strings.
	The conversion characters e, f, and g may be preceded by l, m, or n to indicate that a pointer to double, comp, or extended, rather than float, is in the parameter list.
s	A character string is expected; the corresponding parameter should be a character pointer to an array of characters large enough to accept the string; a terminating null character (\0) is added automatically. The input field is terminated by a white-space (blank or tab) character, or when the number of characters specified by the maximum field width has been read.
c	A character is expected; the corresponding parameter should be a character pointer. The normal skip over white space is suppressed in this case; use %1s to read the next non-white-space character. If a field width is given, the corresponding parameter should refer to a character array; the indicated number of characters is read.

[The left bracket introduces a *scanset* format. The input field is the maximal sequence of input characters consisting entirely of characters in the scanset. When reading the input field, string data and the normal skip over leading white space are suppressed. The corresponding pointer parameter must point to a character array large enough to hold the input field and the terminating null character (`\0`), which will be added automatically. The left bracket is followed by a set of characters (the scanset) and a terminating right bracket.

^ When it appears as the first character in the scanset, the circumflex serves as a complement operator and redefines the scanset as the set of all characters not contained in the remainder of the scanset string.

] The right bracket ends the scanset. To include the right bracket as an element of the scanset, it must appear as the first character (possibly preceded by a circumflex) of the scanset. Otherwise, it will be interpreted syntactically as the closing bracket.

A range of characters may be represented by the construct *first-last;* thus the scanset `[0123456789]` may be expressed `[0-9]`. To use this convention, `first` must be less than or equal to `last` in the ASCII collating sequence. Otherwise, the minus (–) will stand for itself in the scanset. The minus will also stand for itself whenever it is the first or the last character in the scanset.

Conversion terminates at `EOF`, at the end of the control string, or when an input character doesn't match the control string. In the last case, the unmatched character is left unread in the input stream.

Examples

Example 1

The call

```
int i;
float x;
char name[50];
scanf("%d%f%s", &i, &x, name);
```

with input

```
25 54.32E-1 hartwell
```

will assign the value 25 to `i` and the value 5.432 to `x`; name will contain "`hartwell\0`".

Example 2

The call

```
int i;
extended x;
char name[50];
scanf("%2d%nf%*d %[0-9]", &i, &x, name);
```

with input

```
56789 0123 56a72
```

will assign 56 to `i` and 789.0 to `x`, skip 0123, and place the string "`56\0`" in `name`. The next call to `getchar` will return "a".

Example 3

The call

```
int i;
scanf("answer1=%d", &i);
```

with input

```
answer1=51 answer2=45
```

will assign the value 51 to `i` because "`answer1`" is matched explicitly in the input stream; the input pointer will be left at the space before "`answer2`".

Return value

Functions `scanf`, `fscanf`, and `sscanf` return the number of successfully matched and assigned input items; this number can be 0 when an early mismatch between an input character and the control string occurs. If the input ends before the first mismatch or conversion, `EOF` is returned.

These functions return `EOF` on end of input and a short count for missing or illegal data items.

Note

Trailing white space is left unread unless matched in the control string.

The success of literal matches and suppressed assignments is not directly determinable.

Warning

The `pointer` parameters in these functions must be addresses—for example, `&i`. Be sure not to pass `i` rather than its address.

See also

`atof`, `dec2num`, `getc`, `printf`, `stdio`, `str2dec`, `strtol`

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setbuf—assign buffering to a stream

Synopsis

```
#include <StdIO.h>

void setbuf(stream, buf)
  FILE   *stream;
  char   *buf;
int setvbuf(stream, buf, type, size)
  FILE   *stream;
  char   *buf;
  int    type;
  int    size;
```

Description

A buffer is normally allocated by the Standard C Library at the time of the first getc or putc on a file. If you prefer to provide your own buffer, you can call setbuf or setvbuf after a stream has been associated with an open file but before it is read or written. Functions setbuf and setvbuf let you provide your own buffering for a file stream. Function setvbuf is a more flexible extension of setbuf.

Function setbuf causes the character array pointed to by buf to be used instead of an automatically allocated buffer. BUFSIZ, a constant defined in the <StdIO.h> header file, lets you specify the size of the buf array as

```
char buf[BUFSIZ];
```

If buf is NULL, input/output is unbuffered.

Function setvbuf lets you specify two parameters in addition to those required by setbuf: size and type. Parameter size specifies the size in bytes of the array to be used; the standard I/O functions work most efficiently when size is a multiple of BUFSIZ. If buffer pointer buf is NULL, a buffer of size bytes is allocated from the system. If size is not 0, size is assigned to the FILE variable's size parameter; if buf is not NULL, buf is assigned to the FILE variable's buffer-pointer parameter. The value of type determines how stream is buffered by setvbuf:

Value of type	Description
_IOFBF	Causes input/output to be file buffered.
_IOLBF	Causes output to be line buffered. The buffer is flushed when a newline character is written or when the buffer is full.
_IONBF	Causes input/output to be unbuffered. Parameters buf and size are ignored.

The following function calls are equivalent when buf is not NULL:

```
setbuf(stream, buf);
setvbuf(stream, buf, _IOFBF, BUFSIZ);
```

The following function calls are equivalent when `buf` is `NULL`:

```
setbuf(stream, NULL;
setvbuf(stream, NULL, _IONBF, BUFSIZ);
```

Diagnostics

Function `setvbuf` returns nonzero if an invalid value is given for `type`.

Note

The buffer must have a lifetime at least as great as the open stream. Be sure to close the stream before the buffer is deallocated. If you allocate buffer space as an automatic variable in a code block, be sure to close the stream in the same block.

If `buf` is `NULL` and the system cannot allocate `size` bytes, a smaller buffer will be allocated.

See also

`fopen`, `getc`, `malloc`, `putc`, `stdio`

setjmp—nonlocal transfer of control

Synopsis

```
#include <SetJmp.h>

int setjmp(env)
  jmp_buf  env;
void longjmp(env, val)
  jmp_buf  env;
  int      val;
```

Description

These functions let you escape from an error or interrupt encountered in a low-level subroutine of your program.

Function `setjmp` saves its stack environment in `env` for later use by `longjmp`. It returns the value 0.

Function `longjmp` restores the environment saved by the last call of `setjmp` with the corresponding `env` environment. After a call to `longjmp`, the program continues as if the preceding call to `setjmp` had returned the value `val`.

Function `longjmp` cannot cause `setjmp` to return the value 0. If `longjmp` is invoked with a second parameter of 0, `setjmp` returns 1. Data values will be those in effect at the time `longjmp` was called, except for register variables (see "Warning").

Warning

If `longjmp` is called without a previous call to `setjmp` or if the function that contained the `setjmp` has already returned, results are unpredictable.

After a `longjmp`, variables that happen to be assigned to registers are restored to their values before the call to `setjmp`, instead of those in effect at the time `longjmp` was called. To avoid this, declare "important" variables as static. (This will prohibit their use as register variables.)

See also

`signal`

signal—signal handling

Synopsis

```
#include <Signal.h>

typedef unsigned short SignalMap;
typedef int SignalHandler;
SignalHandler *sigset(sigMap, newHandler)
      SignalMap       sigMap;
      SignalHandler   *newHandler;
void _sig_dfl(sigNo, sigState, sigEnabled)
      SignalMap       sigNo;
      SignalMap       sigState;
      SignalMap       sigEnabled;
SignalMap sighold(sigMap)
      SignalMap       sigMap;
void sigrelease(sigMap, prevEnabled)
      SignalMap       sigMap;
      SignalMap       prevEnabled;
void sigpause(sigMap)
      SignalMap       sigMap;
```

Description

C programs that handle software interrupts—known as **signals**—should use these procedures, which support signal handling under MPW. A signal is similar to a hardware interrupt in that its invocation can cause program control to be temporarily diverted from its normal execution sequence; the difference is that the events that raise a signal reflect a change in program state rather than hardware state. Examples of signal events are stack overflow, heap overflow, software floating-point errors, and Command-period interrupts.

Signal handling is available only for tools that run under the MPW Shell; it is not available for applications that run under the Macintosh Finder.

Currently, the only software interrupt provided is Command-period, which is represented by the value `SIGINT`. As additional software interrupts are provided, new values will be added to represent them; the signal-handling procedures will then accept these new signals.

Signals can be caught, held and released, or ignored. The default action of any signal raised is to close all open files, execute any exit procedures installed with `onexit`, and terminate the program. No signal-handling calls are required to execute a normal termination on receipt of a signal. If a program requires special handling of a signal or chooses to ignore it, `sigset` lets you replace the default procedure with a user procedure. You can also temporarily "hold" (that is, suspend) action on a signal by calling `sighold`. You may want to do this before entering a critical section of code. The signal can then be restored by calling the procedure `sigrelease`, whereupon its signal-handling procedure will take effect if the signal was raised since the preceding call to `sighold`. Your program may also wait until one or more signals are raised by calling the `sigpause` procedure.

A signal is represented by a bit in the integer `SignalMap`, which identifies one or more signals to the signal-handling procedures. You can refer to several signals at once by adding or OR-ing their bits together. You can refer to all signals at once by using the value `SIGALLSIGS`.

The sigset function: Function `sigset` replaces the current signal handler (the procedure to be executed upon receipt of the signals specified in `sigMap`) with a user-supplied signal handler. The default signal handler may be set or restored by specifying `SIG_DFL` as the current signal handler. The signals may be ignored entirely by specifying `SIG_IGN` as the current signal handler.

Function `sigset` returns the previous `SignalHandler` pointer. If this pointer must be restored in another part of the program, save the return value and restore it with another call to `sigset`. Multiple signals may be set with one call to `sigset` by OR-ing signal values together in `sigMap`, but in this case `sigset` cannot, of course, return all previous values and its return value is meaningless. To correctly save multiple previous signal handlers, call `sigset` separately for each signal.

The sig_dfl function: This is the default procedure `SIG_DFL`; it is not intended for use by the program directly. It is documented here as an example of a user-supplied signal handler that uses standard C calling conventions.

The first parameter, `sigNo`, is the signal that is being raised. Although it is declared as a `SignalMap`, its value contains at most one signal bit; it can therefore be compared for equality against a signal name, for example, `SIGINT`. The same signal handler may trap several signals with common code and then inspect `sigNo` if special handling of particular signals is required.

The parameters `sigState` and `sigEnabled` provide runtime information about current active signals. Bit map `sigState` describes all raised signals, including signals held by calls to `sighold`. Bit map `sigEnabled` describes all signals currently enabled. By default, all signals are enabled, but they may be disabled by holding them.

Upon entry to a user-supplied signal handler, all signals are temporarily suspended; therefore, the handler is not required to lock out recursive or nested calls to signal handlers. The signal state is restored upon normal return from the signal handler.

Signals cannot be raised while executing in ROM or in the MPW Shell. If a signal event occurs while executing outside the tool, the signal state is set and the signal handler is executed as soon as program control returns to the tool. Because a signal can interrupt the tool at any point, there is no protection against heap corruption if a signal handler executes calls that modify the state of the heap. Because most buffered I/O potentially modifies the heap, `printf` and similar calls are not recommended in signal handlers unless they call `exit` to avoid returning to the application program. Even then, the caller must be careful of interaction between `exit` and `onexit` procedures.

The sighold function: The `sighold` function, like `sigrelease`, permits temporary suspension and restoration of signals. Before a program enters a critical section of code, it should call `sighold` with a signal map of signals to suspend or with the value `SIGALLSIGS`, which represents all signals. Function `sighold` returns a `SignalMap` representing the list of signals already being held; this value should be saved for use as the `prevEnabled` parameter in the subsequent call to `sigrelease`. If the signal event (such as Command-period) occurs after a call to `sighold` is made, the event is recorded in the signal state but the signal handler is not executed.

The sigrelease function: Function `sigrelease` lets you reenable signals that were held by a previous call to `sighold` by specifying their corresponding bits in `sigMap`. Signals that were already on hold when you called `sighold` should be specified to `sigrelease` in the `prevEnabled` parameter to permit correct handling of nested calls to `sighold`. If any of the signal events occurred while they were held, their signal-handling routines will take effect immediately after the return from `sigrelease`. Signal events do not stack; multiple occurrences of signal events that are being held do not yield multiple invocations of the signal handler when the signal is released.

The sigpause function: A call to `sigpause` suspends program activity until a signal event is recorded for any signal not currently held. It is intended for signal synchronization, though in the current implementation its application is limited; it is included here in order to provide a complete signal environment model.

sinh—hyperbolic functions

Synopsis

```
#include <Math.h>

extended sinh(x)
   extended  x;
extended cosh(x)
   extended  x;
extended tanh(x)
   extended  x;
```

Description

Functions `sinh`, `cosh`, and `tanh` return, respectively, the hyberbolic sine, cosine, and tangent of their parameter.

Diagnostics

Functions `sinh`, `cosh`, and `tanh` honor the floating-point exception flags—invalid operation, underflow, overflow, divide by zero, and inexact—as prescribed by SANE.

See also

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stdio—standard buffered input/output package

Synopsis

```
#include <StdIO.h>

FILE *stdin, *stdout, *stderr;
```

Description

The Standard I/O package constitutes an efficient user-level I/O buffering scheme. The inline macros getc and putc handle characters quickly. Macros getchar and putchar, and the higher-level routines fgetc, fgets, fprintf, fputc, fputs, fread, fscanf, fwrite, gets, getw, printf, puts, putw, and scanf, all use getc and putc; calls to these macros and functions can be freely intermixed.

The constants and the following functions are implemented as macros: getc, getchar, putc, putchar, feof, ferror, clearerr, and fileno. Redeclaration of these names should be avoided.

Any program that uses the Standard I/O package must include the <StdIO.h> header file of macro definitions. The functions, macros, and constants used in the Standard I/O package are declared in the header file and need no further declaration.

A *stream* is a file with associated buffering and is declared to be a pointer to a FILE variable. Functions fopen, freopen, and fdopen return this pointer. The information in the FILE variable includes

- the file access—read or write
- the file descriptor as returned by open, creat, dup, or fcntl
- the buffer size and location
- the buffer style (unbuffered, line-buffered, or file-buffered)

Standard I/O buffering: Output streams, with the exception of the standard error stream stderr, are by default file buffered if the output refers to a file. File stderr is by default line buffered. When an output stream is *unbuffered,* it is queued for writing on the destination file or window as soon as written; when it is *file buffered,* many characters are saved up and written as a block; when it is *line buffered,* each line of output is queued for writing as soon as the line is completed (that is, as soon as a newline character is written). Function setvbuf may be used to change the stream's buffering strategy.

Normally, there are three open streams with constant pointers declared in the <StdIO.h> header file and associated with the standard open files:

FILE variable	Fildes	Description	Buffer style
stdin	0	standard input file	file buffered
stdout	1	standard output file	file buffered
stderr	2	standard error file	line buffered

Buffer initialization: The FILE variable returned by fopen, freopen, or fdopen has an initial buffer size of 0 and a NULL buffer pointer. The buffer size is set and the buffer allocated by a call to setbuf, setvbuf, or the first I/O operation on the stream, whichever comes first. Buffer initialization is done using the following algorithm:

1. If _IONBF (no buffering) was set by a call to setvbuf, initialization steps 2 and 3 are skipped. The buffer size remains 0 and the buffer pointer remains NULL.
2. Checks the access-mode word for _IOLBF (line buffering). This bit is usually set only in the predefined file stderr, but a call to setvbuf can set it for any file. If line buffering is set, the buffer size is set to LBUFSIZ (100). If line buffering is not set, ioctl is called with an FIOBUFSIZE request and the buffer size is set to the returned value or to BUFSIZ (1024) if no value is returned.
3. If the buffer pointer is NULL, a request is made for a buffer whose size was determined in step 2; the buffer pointer is set to point to the newly allocated buffer. If the requested size cannot be allocated, attempts are made to allocate BUFSIZ or LBUFSIZ if these are smaller than the requested size. If all requests fail, the buffer pointer remains NULL and the _IONBF (no buffering) bit is set.
4. Function ioctl is called with an FIOINTERACTIVE request; if it returns true, the _IOSYNC bit is set in the access-mode word. This is done for all FILE variables, regardless of their buffering style and size. (The _IOSYNC bit is described in the following section.)

The setvbuf function lets you specify values for buffer size, buffer pointer, and access mode word other than the default values of 0, NULL, and 0, respectively. The setvbuf function must be called before the first I/O operation occurs, so that the buffer initialization procedure described above receives the values you specify instead of the default values.

Buffered I/O: On each write request, the bytes are transferred to the buffer and an internal counter is set to account for the number of bytes in the buffer. If _IOLBF is set and a newline character is encountered while transferring bytes to the buffer, the buffer is flushed (written immediately) and the transfer continues at the beginning of the buffer. This continues until the write-request count is satisfied or a write error occurs.

On each read request, the _IOSYNC bit in the access-mode word is checked. If _IOSYNC is on, all current FILE variables that have _IOSYNC on and are open for writing are flushed. In other words, a read from an interactive FILE variable flushes all interactive output files before reading. This ensures that any prompts, I/O in a window, or other visual feedback is displayed before the read is initiated. Then if the internal counter is 0, an entire buffer is read into memory if possible. (For the console device, less than a buffer's worth is likely to be read.) The bytes required to satisfy the read request are transferred, going back to the device for more if necessary, and an internal pointer is advanced if any bytes remain unread.

When the Standard I/O package is used, Standard I/O cleanup is performed just before termination of the application. Any normal return including a call to `exit` causes Standard I/O cleanup, which consists of a call to `fclose` for every open `FILE` stream.

Note

Do not use a file descriptor (0, 1, or 2) where a `FILE` variable (`stdin`, `stdout`, or `stderr`) is required.

File <StdIO.h> includes definitions other than those described above, but their use is not recommended.

Invalid stream pointers cause serious errors, possibly including program termination. Individual function descriptions describe the possible error conditions.

Diagnostics

An integer constant `EOF` (–1) is returned upon end of file or error by most integer functions that deal with streams. See the descriptions of the individual functions for details.

See Also

`open`, `close`, `lseek`, `read`, `write`, `fclose`, `ferror`, `fopen`, `fread`, `fseek`, `getc`, `gets`, `printf`, `putc`, `puts`, `scanf`, `setbuf`, `ungetc`

string—string operations

Synopsis

```
char *strcat(destStr, srcStr)
      char   *destStr, *srcStr;
char *strncat(destStr, srcStr, n)
      char   *destStr, *srcStr;
      int    n;
int strcmp(str1, str2)
      char   *str1, *str2;
int strncmp(str1, str2, n)
      char   *str1, *str2;
      int    n;
char *strcpy(destStr, srcStr)
      char   *destStr, *srcStr;
char *strncpy(destStr, srcStr, n)
      char   *destStr, *srcStr;
      int    n;
int strlen(str)
      char   *str;
char *strchr(str, c)
      char   *str, c;
char *strrchr(str, c)
      char   *str, c;
char *strpbrk(srcStr, findChars)
      char   *srcStr, *findChars;
int strspn(srcStr, spanChars)
      char   *srcStr, *spanChars;
int strcspn(srcStr, skipChars)
      char   *srcStr, *skipChars;
char *strtok(destStr, tokenStr)
      char   *destStr, *tokenStr;
```

Description

The string parameters (`srcStr`, `destStr`, and so forth) and `s` point to arrays of characters terminated by a null character. The functions `strcat`, `strncat`, `strcpy`, and `strncpy` all alter `destStr`. These functions do not check for overflow of the array pointed to by `destStr`.

Function `strcat` appends a copy of string `srcStr` to the end of string `destStr`. Function `strncat` appends at most n characters. Each function returns a pointer to the null-terminated result.

Function `strcmp` performs a comparison of its parameters according to the ASCII collating sequence and returns an integer less than, equal to, or greater than 0 when `str1` is less than, equal to, or greater than `str2`, respectively. Function `strncmp` makes the same comparison but looks at a maximum of n characters.

Function `strcpy` copies string `srcStr` to string `destStr`, stopping after the null character has been copied. Function `strncpy` copies exactly n characters, truncating `srcStr` or adding null characters to `destStr` if necessary. The result is not terminated with a null if the length of `srcStr` is n or more. Each function returns `destStr`.

Function `strlen` returns the number of characters in `str`, not including the terminating null character.

Functions `strchr` and `strrchr` both return a pointer to the first and last occurrence, respectively, of character `c` in string `str`; they return a null pointer if `c` does not occur in the string. The null character terminating a string is considered to be part of the string. In previous versions of the Standard C Library, `strchr` was known as `index` and `strrchr` was known as `rindex`.

Function `strpbrk` returns a pointer to the first occurrence in string `srcStr` of any character from string `findChars`, or a null pointer if no character from `findChars` exists in `srcStr`.

Function `strspn` returns the length of the initial segment of string `srcStr` that consists entirely of characters from string `spanChars`.

Function `strcspn` returns the length of the initial segment of string `srcStr` that consists entirely of characters not from string `skipChars`.

Function `strtok` considers the string `destStr` as a sequence of zero or more text tokens separated by spans of one or more characters from the separator string `tokenStr`. The first call (with pointer `destStr` specified) returns a pointer to the first character of the first token and writes a null character into `destStr` immediately following the returned token. The function keeps track of its position in the string between calls. Subsequent calls for the same string must be made with a null pointer as the first parameter. The separator string `tokenStr` may be different from call to call. When no token remains in `destStr`, a null pointer is returned.

Warning Overlapping moves yield unexpected results.

Functions `strcmp` and `strncmp` use signed arithmetic when comparing their parameters. The sign of the result will be incorrect for characters with values greater than `0x7F` in the Macintosh extended character set.

See also `BlockMove`, `EqualString`, `memory`

strtol—convert a string to a long

Synopsis

```
long strtol(str, ptr, base)
      char   *str;
      char   **ptr;
      int    base;
```

Description

Function `strtol` returns a `long` containing the value represented by the character string `str`. The string is scanned up to the first character inconsistent with the base (decimal, hexadecimal, or octal). Leading white-space characters are ignored.

If the value of `ptr` is not `NULL`, a pointer to the character terminating the scan is returned in `*ptr`. If no integer can be formed, `*ptr` is set to `str` and 0 is returned.

If `base` is `0`, the base is determined from the string. If the first character after an optional leading sign is not `0`, decimal conversion is done; if the `0` is followed by `x` or `X`, hexadecimal conversion is done; otherwise octal conversion is done.

The function call `atol(str)` is equivalent to

```
strtol(str, (char **)NULL, 10)
```

The function call `atoi(str)` is equivalent to

```
(int) strtol(str, (char **)NULL, 10)
```

Note

Overflow conditions are ignored.

Apple base conventions (`$` for hexadecimal, `%` for binary) are not supported.

See Also

`atof`, `atoi`, `scanf`

trig—trigonometric functions

Synopsis

```
#include <Math.h>
extended sin(x)
      extended  x;
extended cos(x)
      extended  x;
extended tan(x)
      extended  x;
extended asin(x)
      extended  x;
extended acos(x)
      extended  x;
extended atan(x)
      extended  x;
extended atan2(y, x)
      extended  y, x;
```

Description

Functions `sin`, `cos`, and `tan` return, respectively, the sine, cosine, and tangent of their argument, which is in radians.

Function `asin` returns the arcsine of x, in the range $-\pi/2$ to $\pi/2$.

Function `acos` returns the arccosine of x, in the range 0 to π.

Function `atan` returns the arctangent of x, in the range $-\pi/2$ to $\pi/2$.

Function `atan2` returns the arctangent of `y/x`, in the range $-\pi$ to π, using the signs of both arguments to determine the quadrant of the return value.

For special cases, these functions return a NaN or infinity as appropriate.

Diagnostics

These functions honor the floating-point exception flags—invalid operation, underflow, overflow, divide by zero, and inexact—as prescribed by SANE.

Note

Functions `sin`, `cos`, and `tan` have periods based on the nearest extended-precision representation of mathematical π. Hence these functions diverge from their mathematical counterparts as their argument becomes far from zero.

See also

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ungetc—push a character back into the input stream

Synopsis

```
#include <StdIO.h>

int ungetc(c, stream)
      char      c;
      FILE      *stream;
```

Description

Function ungetc inserts the character c into the buffer associated with an input stream. The stream must be file buffered or line buffered; it cannot be unbuffered. The inserted character, c, will be returned by the next getc call on that stream. Function ungetc returns c and leaves the file stream unchanged.

Only one character of pushback is allowed, provided something has been read from the stream and the stream is not unbuffered.

If c equals EOF, ungetc does nothing to the buffer and returns EOF. In other words, you cannot use ungetc to force end of file the next time the file is read.

Function fseek undoes the effect of ungetc.

Diagnostics

For ungetc to perform correctly, a read must have been performed before the call to the ungetc function. Function ungetc returns EOF if it can't insert the character.

Note

Function ungetc does not work on unbuffered streams.

See also

fseek, getc, setbuf, stdio

unlink—delete a named file

Synopsis

```
int unlink(fileName)
       char       *fileName;
```

Description

Function `unlink` deletes the named file. The function fails if the named file is open. A call to `unlink` is equivalent to

```
faccess(fileName, F_DELETE)
```

Diagnostics

Upon successful completion, a value of 0 is returned. Otherwise, a value of –1 is returned and `errno` is set to indicate the error.

See also

`faccess`

write—write on a file

Synopsis

```
int write(fildes, buf, nbyte)
      int       fildes;
      char      *buf;
      unsigned  nbyte;
```

Description

File descriptor `fildes` is obtained from an open, `creat`, dup, or `fcntl` call.

Function `write` attempts to write nbyte bytes from the buffer pointed to by `buf` to the file associated with the `fildes`. Internal limitations may cause `write` to write fewer bytes than requested; the number of bytes actually written is indicated by the return value. Several calls to `write` may therefore be necessary to write out the contents of `buf`.

On devices capable of seeking, the actual writing of data proceeds from the position in the file indicated by the file pointer. Upon return from `write`, the file pointer is incremented by the number of bytes actually written.

On nonseeking devices, writing starts at the current position. The value of a file pointer associated with such a device is undefined.

If the O_APPEND file status flag set in open is on, the file pointer is set to end of file before each write.

The file pointer remains unchanged and `write` fails if `fildes` is not a valid file descriptor open for writing. [EBADF]

If you try to write more bytes than there is room for on the device, `write` writes as many bytes as possible. For example, if `nbyte` is 512 and there is room for 20 bytes more on the device, `write` writes 20 bytes and returns a value of 20. The next attempt to write a nonzero number of bytes will return an error. [ENOSPC]

File descriptor 1 is standard output; file descriptor 2 is standard error.

Return value

Upon successful completion, the number of bytes actually written is returned. Otherwise, –1 is returned and `errno` is set to indicate the error.

See also

`creat`, `lseek`, `open`

Chapter 4

The Macintosh Interface Libraries

About the Macintosh Interface Libraries

This chapter contains the C definitions of the constants, types, and functions defined in *Inside Macintosh*. The information here is the C equivalent of the Pascal definitions in the Summary sections at the end of each chapter of *Inside Macintosh*. Complete documentation for each of the constants, types, and functions defined here is found in the corresponding section of *Inside Macintosh*.

❖ *Note:* If you have a Macintosh Plus or a Macintosh 512K enhanced—with 128K ROM—you have access to all of the Macintosh Interface Libraries. If you have a Macintosh with 64K ROM, you have access only to the libraries documented in *Inside Macintosh*, Volumes 1-3; you don't have access to those documented in *Inside Macintosh*, Volume 4. Parts of the FixMath library are available in a RAM library for 64K ROM users. Graf3D is available in a library for all users.

After an introductory description of the interface, this chapter is arranged alphabetically by library name. The libraries are documented in the manner described in the section "About the Standard C Library" in Chapter 3. All of the identifiers in the Macintosh Interface Libraries are listed in Appendix C, "The Library Index."

Header files

Include the ".h" header files in C programs to declare the defines, types, and functions provided by these libraries. Each library definition lists the include directives necessary for use of that library. Functions whose declarations can be inferred from calls (that is, integer functions) have been omitted from the header files, to improve the Compiler's efficiency.

How the interface is implemented

Many Macintosh Interface Libraries routines are declared as external Pascal routines with trap numbers and are trapped to directly by compiled code. You cannot take the addresses of these functions. Other routines are declared to be C routines and are called through interface code.

The interface code is contained in files {CLibraries}CInterface.o and {Libraries}Interface. Link these files with the C program and other libraries. Not all functions require interface code. The Linker includes interface code for only those routines that are called.

Parameter types

The C interfaces expect small structures, like `Points`, to be passed by address. String parameters are null-terminated C strings unless otherwise indicated. `ResTypes` and `OSTypes` can be expressed as character literals; for example, `'MENU'`. All `VAR` parameters in `extern pascal` declarations must be passed explicitly by address.

All structures are passed to the ROM interface procedures by means of a pointer. The ROM actually expects small structures to be passed by value: that is, if the structure is four bytes or less in size, Pascal calling conventions dictate that the structure should itself be pushed on the stack. When this convention disagrees with what the ROM expects, assembly-language "glue" procedures provide the proper interface.

Passing string parameters

In general, C programmers use strings like

```
"hello, world\n"
```

which is an array of characters whose last element is the null byte (`'\0'`).

The Macintosh ROM, however, expects Pascal strings, which have an initial byte of `count` with the string following (and no null byte at the end).

Because both strings have an extra byte of information (either a count at the beginning or a null byte at the end), it is possible to transform a string *in place* from a Pascal string into a C string and vice versa. The routines `c2pstr()` and `p2cstr()` in the library CInterface.o perform these conversions (see the Strings page in this chapter).

The interface routines in CInterface.o do these conversions for you automatically. Whenever you call a ROM interface routine and one of the parameters is a string (that is, a pointer to `char`, of type `Str255` in *Inside Macintosh*), you should pass a C string. Then the interface routine performs the following actions:

1. converts the input strings from C strings into Pascal strings
2. fixes up the stack so the parameters conform to Pascal calling conventions
3. calls the ROM
4. converts the output strings from Pascal strings back into C strings

Therefore you always pass C strings to the ROM interface procedures and receive C strings in return.

Note that the conversions happen only when the string is as *parameter* to the interface routine. If the string is a field of a structure passed to the ROM, then *no* conversion is performed.

Any exceptions to this rule will be noted in the Warning section of the appropriate manual page in this chapter.

Finally, if you have a Pascal string and want to convert it into a C string (for example, before you call a ROM interface procedure), you can do so with the routine `p2cstr()`. The routine `c2pstr()` converts a C string into a Pascal string. Both conversions are done in place.

❖ *Note:* If you want to create your own Pascal string, simply preface your string with a byte count, in this way:

```
char *pascalstring = "\005hello";
```

This puts an extra null byte at the end, but has the following properties:

`&pascalstring[0]` is a pointer to a Pascal string.

`&pascalstring[1]` is a pointer to a C string.

Of course, in an application most strings come from resources rather than constants in your program. This allows your application to be altered with the resource editor (for internationalization or customization).

Correspondences between Pascal variant records and C structs

Some of the `variant records` in *Inside Macintosh* are implemented in the MPW C header files by means of multiple distinct `struct` declarations. (The reader might have expected unions.) Table 4-1 is a list of `variant record` types, with references to *Inside Macintosh* and to the MPW C manual page (in this chapter) and corresponding C `struct` name.

Table 4-1
Correspondences between variant records and structs

Inside Macintosh		*MPW C Reference*	
variant record	**Chapter (volume)**	**struct**	**Manual page**
`ABusRecord`	AppleTalk [2]	`ATLAPRec`	AppleTalk
`ABusRecord`	AppleTalk [2]	`ATDDPRec`	AppleTalk
`ABusRecord`	AppleTalk [2]	`ATNBPRec`	AppleTalk
`ABusRecord`	AppleTalk [2]	`ATDDPRec`	AppleTalk
`ParamBlockRec`	File Manager [2]	`CntrlParam`	Devices
`ParamBlockRec`	File Manager [2]	`ParamBlockRec`	Files
`QElem`	O. S. Utilities[2]	`QElem`	Osutils
`DrvSts`	Disk Driver	`DrvSts`	Disks
`DrvSts`	Disk Driver	`DrvSts2`	Disks
`Point`	Quickdraw [1]	`Point`	Types
`Rect`	Quickdraw [1]	`Rect`	Types

InterfaceC interface to the Macintosh libraries

Synopsis

```
#include  <Types.h>        /* common defines and types */
#include  <Resources.h>   /* Resource Manager */
#include  <QuickDraw.h>   /* QuickDraw */
#include  <Windows.h>     /* Window Manager */
#include  <OSUtils.h>     /* Operating System Utilities */
#include  <AppleTalk.h>   /* AppleTalk Manager */
#include  <Controls.h>    /* Control Manager */
#include  <Desk.h>        /* Desk Manager */
#include  <Devices.h>     /* Device Manager */
#include  <Dialogs.h>     /* Dialog Manager */
#include  <Disks.h>       /* Disk Driver */
#include  <Errors.h>      /* System Error Handler */
#include  <Events.h>      /* Event Manager */
#include  <Files.h>       /* File Manager */
#include  <FixMath.h>     /* fixed-point arithmetic */
#include  <Fonts.h>       /* Font Manager */
#include  <Graf3D.h>      /* Graf3D */
#include  <Lists.h>       /* List Manager */
#include  <Memory.h>      /* Memory Manager */
#include  <Menus.h>       /* Menu Manager */
#include  <OSEvents.h>    /* OS Event Manager */
#include  <Packages.h>    /* packages */
#include  <Printing.h>    /* Printing Manager */
#include  <Retrace.h>     /* Vertical Retrace Manager */
#include  <SANE.h>        /* SANE Numerics */
#include  <Scrap.h>       /* Scrap Manager */
#include  <SCSI.h>        /* SCSI Manager */
#include  <SegLoad.h>     /* Segment Loader */
#include  <Serial.h>      /* Serial Drivers */
#include  <Sound.h>       /* Sound Driver */
#include  <Strings.h>     /* string conversions */
#include  <TextEdit.h>    /* TextEdit */
#include  <Time.h>        /* Time Manager Package */
#include  <ToolUtils.h>   /* Toolbox Utilities */
```

Description

The C Interface provides C programs with access to all of the libraries defined in *Inside Macintosh*. Constants, types, and library routines are provided. The list of libraries appears in the Synopsis.

Note

List the first five `#include` directives in the order in which the libraries are listed above. The order of the other `#include` directives is irrelevant.

AppleTalk—AppleTalk Manager

Synopsis

```
#include  <Types.h>
#include  <AppleTalk.h>
#define   lapSize              20  /* ABusRecord size for ALAP */
#define   ddpSize              26  /* ABusRecord size for DDP */
#define   nbpSize              26  /* ABusRecord size for NBP */
#define   atpSize              56  /* ABusRecord size for ATP */
#define   nbpBuffOvr     (-1024)
#define   nbpNoConfirm   (-1025)
#define   nbpConfDiff    (-1026)
#define   nbpDuplicate   (-1027)
#define   nbpNotFound    (-1028)
#define   reqFailed      (-1096)
#define   tooManyReqs    (-1097)
#define   tooManySkts    (-1098)
#define   badATPSkt      (-1099)
#define   badBuffNum     (-1100)
#define   cbNotFound     (-1102)
#define   noSendResp     (-1103)
#define   noDataArea     (-1104)
#define   reqAborted     (-1105)
#define   atpBadRsp      (-3107)
#define   recNotFnd      (-3108)

typedef enum {
   tLAPRead,tLAPWrite,tDDPRead,tDDPWrite,tNBPLookup,
   tNBPConfirm,tNBPRegister,tATPSndRequest,tATPGetRequest,
   tATPSdRsp,tATPAddRsp,tATPRequest,tATPResponse
} ABCallType; /* type of call */
typedef enum { lapProto,ddpProto,nbpProto,atpProto } ABProtoType;
typedef struct LAPAdrBlock {
   unsigned char   dstNodeID,srcNodeID,lapProtType;
} LAPAdrBlock;

typedef struct AddrBlock {
   short           aNet;
   unsigned char   aNode,aSocket;
} AddrBlock;

typedef struct EntityName {
   String(32)      objStr,typeStr,zoneStr;
} EntityName, *EntityPtr;

typedef struct RetransType {
   unsigned char   retransInterval,retransCount;
} RetransType;
typedef char BitMapType;
typedef struct BDSElement {
  short          buffSize;
  Ptr            buffPtr;
  short          dataSize;
  long           userBytes;
} BDSElement, BDSType[8];
typedef BDSType *BDSPtr;

typedef struct ATLAPRec {
  ABCallType     abOpcode; /* type of call */
  short          abResult;         /* result code */
  long           abUserReference;  /* for your use */
  LAPAdrBlock    lapAddress;
  short          lapReqCount;
  short          lapActCount;
  Ptr            lapDataPtr;
} ATLAPRec,*ATLAPRecPtr,**ATLAPRecHandle;

typedef struct ATDDPRec {
  ABCallType     abOpcode;
  short          abResult;
  long           abUserReference;
  short          ddpType;
  short          ddpSocket;
  AddrBlock      ddpAddress;
  short          ddpReqCount;
  short          ddpActCount;
  Ptr            ddpDataPtr;
  short          ddpNodeID;
} ATDDPRec,*ATDDPRecPtr,**ATDDPRecHandle;

typedef struct ATNBPRec {
  ABCallType     abOpcode;
  short          abResult;
  long           abUserReference;
  EntityPtr      nbpEntityPtr;
  Ptr            nbpBufPtr;
  short          nbpBufSize;
  short          nbpDataField;
  AddrBlock      nbpAddress;
  RetransType    nbpRetransmitInfo;
} ATNBPRec, *ATNBPRecPtr, **ATNBPRecHandle;

typedef struct ATATPRec {
  ABCallType     abOpcode;
  short          abResult;
  long           abUserReference;
  short          atpSocket;
  AddrBlock      atpAddress;
  short          atpReqCount;
  Ptr            atpDataPtr;
  BDSPtr         atpRspBDSPtr;
  BitMapType     atpBitMap;
```

```
   short          atpTransID;
   short          atpActCount;
   long           atpUserData;
   Boolean        atpXO;
   Boolean        atpEOM;
   short          atpTimeOut;
   short          atpRetries;
   short          atpNumBufs;
   short          atpNumRsp;
   short          atpBDSSize;
   long           atpRspUData;
   Ptr            atpRspBuf;
   short          atpRspSize
} ATATPRec, *ATATPRecPtr, **ATATPRecHandle;

/* Opening and Closing AppleTalk */

pascal short MPPOpen();
pascal short MPPClose();

/* AppleTalk Link Access Protocol */

pascal short LAPOpenProtocol(theLAPType,protoPtr)
   short theLAPType;
   Ptr protoPtr;
pascal short LAPCloseProtocol(theLAPType)
   short theLAPType;
pascal short LAPWrite(abRecord,async)
   ATLAPRecHandle abRecord;
   Boolean async;
pascal short LAPRead(abRecord,async)
   ATLAPRecHandle abRecord;
   Boolean async;
pascal short LAPRdCancel(abRecord)
   ATLAPRecHandle abRecord;

/* Datagram Delivery Protocol */

pascal short DDPOpenSocket(theSocket,sktListener)
   short *theSocket;
   Ptr sktListener;
pascal short DDPCloseSocket(theSocket)
   short theSocket;
pascal short DDPWrite(abRecord,doChecksum,async)
   ATDDPRecHandle abRecord;
   Boolean doChecksum,async;
pascal short DDPRead(abRecord,retCksumErrs,async)
   ATDDPRecHandle abRecord;
   Boolean retCksumErrs;
   Boolean async;
pascal short DDPRdCancel(abRecord)
   ATDDPRecHandle abRecord;
```

```
/* AppleTalk Transaction Protocol */

pascal short ATPLoad();
pascal short ATPUnload();
pascal short ATPOpenSocket(addrRcvd,atpSocket)
  AddrBlock addrRcvd;
  short *atpSocket;
pascal short ATPCloseSocket(atpSocket)
  short atpSocket;
pascal short ATPSndRequest(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;
pascal short ATPRequest(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;
pascal short ATPReqCancel(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;
pascal short ATPGetRequest(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;
pascal short ATPSndRsp(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;
pascal short ATPAddRsp(abRecord)
  ATATPRecHandle abRecord;
pascal short ATPResponse(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;
pascal short ATPRspCancel(abRecord,async)
  ATATPRecHandle abRecord;
  Boolean async;

/* Name-Binding Protocol */

pascal short NBPRegister(abRecord,async)
  ATNBPRecHandle abRecord;
  Boolean async;
pascal short NBPLookup(abRecord,async)
  ATNBPRecHandle abRecord;
  Boolean async;
pascal short NBPExtract(theBuffer,numInBuf,whichOne,abEntity,address)
  Ptr theBuffer;
  short numInBuf;
  short whichOne;
  EntityName *abEntity;
  AddrBlock *address;
pascal short NBPConfirm(abRecord,async)
  ATNBPRecHandle abRecord;
  Boolean async;
pascal short NBPRemove(abEntity)
  EntityPtr abEntity;
pascal short NBPLoad();
pascal short NBPUnload();
```

```
/* Miscellaneous Routines */

pascal void RemoveHdlBlocks();
pascal short GetNodeAddress(myNode,myNet)
   short *myNode,
   short *myNet;
pascal Boolean IsMPPOpen();
pascal Boolean IsATPOpen();
```

Description

The AppleTalk Manager provides an interface to the .MPP and .ATP AppleTalk device drivers in the 128K ROM.

For more detailed information, see the AppleTalk Manager chapter of *Inside Macintosh.*

Note

Because C does not have variant records like Pascal, some Pascal records in *Inside Macintosh* are represented by more than one C `typedef` in this interface.

Controls—Control Manager

Synopsis

```
#include  <Types.h>
#include  <QuickDraw.h>
#include  <Controls.h>

/* Control Definition Procedures IDs */

#define   pushButProc      0
#define   checkBoxProc     1
#define   radioButProc     2
#define   useWFont         8
#define   scrollBarProc   16

/* FindControl Result Codes */

#define   inButton        10
#define   inCheckBox      11
#define   inUpButton      20
#define   inDownButton    21
#define   inPageUp        22
#define   inPageDown      23
#define   inThumb        129

/* DragControl Axis Constraints */

#define   noConstraint     0
#define   hAxisOnly        1
#define   vAxisOnly        2

/* Messages to Control Definition Function */

#define   drawCntl         0
#define   testCntl         1
#define   calcCRgns        2
#define   initCntl         3
#define   dispCntl         4
#define   posCntl          5
#define   thumbCntl        6
#define   dragCntl         7
#define   autoTrack        8

typedef struct ControlRecord {
   struct ControlRecord  **nextControl;
   struct GrafPort       *contrlOwner;
   Rect                  contrlRect;
   unsigned char         contrlVis;
   unsigned char         contrlHilite;
   short                 contrlValue;
```

```
    short                   contrlMin;
    short                   contrlMax;
    Handle                  contrlDefProc;
    Handle                  contrlData;
    ProcPtr                 contrlAction;
    long                    contrlRfCon;
    Str255                  contrlTitle;
} ControlRecord,*ControlPtr,**ControlHandle;

/* Initialization and Allocation */

ControlHandle NewControl(theWindow,boundsRect,title,visible,value,
      min,max,procID,refCon)
    struct GrafPort *theWindow;
    Rect                    *boundsRect;
    char                    *title;
    Boolean                 visible;
    short                   value;
    short                   min;
    short                   max;
    short                   procID;
    long                    refCon;
pascal ControlHandle GetNewControl(controlID,theWindow)
    short                   controlID;
    struct GrafPort         *theWindow;
pascal void DisposeControl(theControl)
    ControlHandle           theControl;
pascal void KillControls(theWindow)
    struct GrafPort         *theWindow;

/* Control Display */

void SetCTitle(theControl,title)
    ControlHandle           theControl;
    char                    *title;
void GetCTitle(theControl,title)
    ControlHandle           theControl;
    char                    *title;
pascal void HideControl(theControl)
    ControlHandle           theControl;
pascal void ShowControl(theControl)
    ControlHandle           theControl;
pascal void DrawControls(theWindow)
    struct GrafPort         *theWindow;
pascal void Draw1Control(theControl)
    ControlHandle           theControl;
pascal void HiliteControl(theControl,hiliteState)
    ControlHandle           theControl;
    short                   hiliteState;
pascal void UpdtControl(theWindow,updateRgn)
    struct GrafPort         *theWindow;
    RgnHandle               updateRgn;
```

```
/* Mouse Location */

short FindControl(thePoint,theWindow,whichControl)
  Point                  *thePoint;
  struct GrafPort        *theWindow;
  ControlHandle          *whichControl;
short TrackControl(theControl,startPt,actionProc)
  ControlHandle          theControl;
  Point                  *startPt;
  ProcPtr                actionProc;
short TestControl(theControl,thePoint)
  ControlHandle          theControl;
  Point                  *thePoint;

/* Control Movement and Sizing */

pascal void MoveControl(theControl,h,v)
  ControlHandle          theControl;
  short                  h;
  short                  v;
void DragControl(theControl,startPt,limitRect,slopRect,axis)
  ControlHandle          theControl;
  Point                  *startPt;
  Rect                   *limitRect;
  Rect                   *slopRect;
  short                  axis;
pascal void SizeControl(theControl,w,h)
  ControlHandle          theControl;
  short                  w;
  short                  h;

/* Control Setting and Range */

pascal void SetCtlValue(theControl,theValue)
  ControlHandle theControl;
  short theValue;
pascal short GetCtlValue(theControl)
  ControlHandle theControl;
pascal void SetCtlMin(theControl,minValue)
  ControlHandle theControl;
  short minValue;
pascal short GetCtlMin(theControl)
  ControlHandle theControl;
pascal void SetCtlMax(theControl,maxValue)
  ControlHandle theControl;
  short maxValue;
pascal short GetCtlMax(theControl)
  ControlHandle theControl;

/* Miscellaneous Routines */

pascal void SetCRefCon(theControl,data)
  ControlHandle theControl;
  long data;
pascal long GetCRefCon(theControl)
  ControlHandle theControl;
pascal void SetCtlAction(theControl,actionProc)
  ControlHandle theControl;
  ProcPtr actionProc;
pascal ProcPtr GetCtlAction(theControl)
  ControlHandle theControl;
```

User routines

```
pascal void MyAction();
pascal void MyAction(theControl,partCode)
  ControlHandle theControl;
  short partCode;
pascal long MyControl(varCode,theControl,message,param)
  short varCode;
  ControlHandle theControl;
  short message;
  long param;
```

Description

The Control Manager provides routines for creating and manipulating controls (for example, buttons and scroll bars).

For more detailed information, see the Control Manager chapter of *Inside Macintosh.*

Desk—Desk Manager

Synopsis

```
#include  <Types.h>
#include  <Desk.h>

#define   accEvent 64
#define   accRun 65
#define   accCursor 66
#define   accMenu 67
#define   accUndo 68
#define   accCut 70
#define   accCopy 71
#define   accPaste 72
#define   accClear 73

/* Opening and Closing Desk Accessories */

short OpenDeskAcc(theAcc)
   char *theAcc;
pascal void CloseDeskAcc(refNum)
   short refNum;

/* Handling Events in Desk Accessories */

pascal void SystemClick(theEvent,theWindow)
   struct EventRecord *theEvent;
   struct GrafPort *theWindow;
pascal Boolean SystemEdit(editCmd)
   short editCmd;

/* Performing Periodic Actions */

pascal void SystemTask();

/* Advanced Routines */

pascal Boolean SystemEvent(theEvent)
   struct EventRecord *theEvent;
pascal void SystemMenu(menuResult)
   long menuResult;
```

Description

The Desk Manager supports desk accessories.

For more detailed information, see the Desk Manager chapter of *Inside Macintosh*.

Note

Desk accessories do not have an A5 global area. Therefore all of the code for a desk accessory must reside in a single segment, no global variables may be declared, and no string constants may be used.

Warning

The names of desk accessories start with a null byte. The output parameter from `GetMenuItem` will return a string that begins with a null byte when a desk accessory is selected from the Apple menu. `OpenDeskAcc` skips over this null byte (if present) when interpreting its parameter.

Devices—device Manager

Synopsis

```
#include  <Types.h>
#include  <OSUtils.h>
#include  <Windows.h>
#include  <Files.h>
#include  <Devices.h>
#define   fsAtMark        0
#define   fsCurPerm       0
#define   fsRdPerm        1
#define   fsWrPerm        2
#define   fsRdWrPerm      3
#define   fsRdWrShPerm    4

/* Chooser Message Values */

#define   newSelMsg      12   /* new user selections have been made */
#define   fillListMsg    13   /* fill the list with choices to be made */
#define   getSelMsg      14   /* mark one or more choices as selected */
#define   selectMsg      15   /* a choice has actually been made */
#define   deselectMsg    16   /* a choice has been canceled */
#define   terminateMsg   17   /* lets device package clean up */
#define   buttonMsg      19   /*  */

/* Caller Values */

#define      chooserID      1        /* caller value for the Chooser */

typedef struct CntrlParam {
  struct QElem  *qLink;         /* next queue entry */
  short         qType;          /* queue type */
  short         ioTrap;         /* routine trap */
  Ptr           ioCmdAddr;      /* routine address */
  ProcPtr       ioCompletion;   /* completion routine */
  OSErr         ioResult;       /* result code */
  char          *ioNamePtr;     /* driver name */
  short         ioVRefNum;      /* volume reference or drive number */
  short         ioCRefNum;      /* driver reference number */
  short         csCode;         /* word for control status code */
  short         csParam[11]     /* operation-defined parameters */
} CntrlParam;

typedef struct DCtlEntry {
  Ptr             dCtlDriver;     /* ptr to ROM or handle to RAM driver */
  short           dCtlFlags;      /* flags */
  QHdr            dCtlQHdr;       /* driver's I/O queue */
  long            dCtlPosition;   /* byte pos used by read and write */
  Handle          dCtlStorage;    /* handle to RAM driver's storage */
  short           dCtlRefNum;     /* driver's reference number */
  long            dCtlCurTicks;   /* counter for timing system task calls */
  struct GrafPort  *dCtlWindow;    /* ptr to driver's window (if any) */
  short            dCtlDelay;      /* # of ticks between sysTask calls */
  short            dCtlEMask;      /* desk accessory event mask */
  short            dCtlMenu;       /* menu ID of menu associated w/driver */
} DCtlEntry,*DCtlPtr,**DCtlHandle;

/* High-Level Routines */

OSErr OpenDriver(name,refNum)
  char *name;
  short *refNum;
OSErr CloseDriver(refNum)
  short refNum;
OSErr FSRead(refnum,count,buffPtr)
  short refnum;
  long *count;
  Ptr buffPtr;
OSErr FSWrite(refnum,count,buffPtr)
  short refnum;
  long *count;
  Ptr buffPtr;
OSErr Control(refNum,csCode,csParamPtr)
  short refNum;
  short csCode;
  Ptr csParamPtr;
OSErr Status(refNum,csCode,csParamPtr)
  short refNum;
  short csCode;
  Ptr csParamPtr;
OSErr KillIO(refNum)
  short refNum;

/* Low-Level Routines */

OSErr PBOpen(paramBlock,async)
  struct ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBClose(paramBlock,async)
  struct ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBRead(paramBlock,async)
  struct ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBWrite(paramBlock,async)
  struct ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBControl(paramBlock,async)
  CntrlParam *paramBlock;
  Boolean async;
OSErr PBStatus(paramBlock,async)
  CntrlParam *paramBlock;
  Boolean async;
OSErr PBKillIO(paramBlock,async)
```

```
  CntrlParam *paramBlock;
  Boolean async;

/* Accessing a Driver's I/O Queue */

DCtlHandle GetDCtlEntry(refNum)
  short refNum;
```

User routines

```
pascal OSErr Device(message,caller,objName,zoneName,p1,p2)
  short message;
  short caller;
  char *objName;
  char *zoneName;
  long p1, p2;
```

Description

The Device Manager controls the exchange of information between applications and devices.

For more detailed information, see the Device Manager chapter of *Inside Macintosh*.

Warning

The parameters `objName` and `zoneName` to the user routine `Device` must be Pascal strings.

Dialogs—Dialog Manager

Synopsis

```
#include  <Types.h>
#include  <QuickDraw.h>
#include  <Windows.h>
#include  <Dialogs.h>

/* Item Types */

#define  ctrlItem      4  /* add to following four constants */
#define  btnCtrl       0  /* standard button control */
#define  chkCtrl       1  /* standard check box control */
#define  radCtrl       2  /* standard "radio button" control */
#define  resCtrl       3  /* control defined in control template */
#define  statText      8  /* static text */
#define  editText     16  /* editable text (dialog only) */
#define  iconItem     32  /* icon */
#define  picItem      64  /* Quickdraw picture */
#define  userItem      0  /* application-defined item (dialog only) */
#define  itemDisable 128  /* add to any of above to disable */

/* Item Numbers of OK and Cancel Buttons */

#define  ok            1  /* OK button is first by convention */
#define  cancel        2  /* Cancel button is second by convention */

/* Resource IDs of Alert Icons */

#define  stopIcon      0
#define  noteIcon      1
#define  cautionIcon   2
typedef WindowPtr DialogPtr;

typedef struct DialogRecord {
   WindowRecord  window;
   Handle        items;
   struct TERec  **          textH;
   short         editField;
   short         editOpen;
   short         aDefItem;
} DialogRecord, *DialogPeek;

typedef struct DialogTemplate {
   Rect      boundsRect;
   short     procID;
   Boolean   visible;
   Boolean   filler1;
   Boolean   goAwayFlag;
   Boolean   filler2;
```

```
  long      refCon;
  short     itemsID;
  Str255    title;
} DialogTemplate,*DialogTPtr,**DialogTHndl;

typedef short StageList;

typedef struct AlertTemplate {
  Rect                boundsRect;
  short               itemsID;
  StageList stages;
} AlertTemplate,*AlertTPtr,**AlertTHndl;

/* Initialization */

pascal void InitDialogs(resumeProc)
  ProcPtr resumeProc;
pascal void ErrorSound(soundProc)
  ProcPtr soundProc;
void SetDAFont(fontNum)
  short fontNum;

/* Creating and Disposing of Dialogs */

DialogPtr NewDialog(dStorage,boundsRect,title,visible,procID,behind,
     goAwayFlag,refCon,items)
  Ptr dStorage;
  Rect *boundsRect;
  char *title;
  Boolean visible;
  short procID;
  WindowPtr behind;
  Boolean goAwayFlag;
  long refCon;
  Handle items;
pascal DialogPtr GetNewDialog(dialogID,dStorage,behind)
  short dialogID;
  Ptr dStorage;
  WindowPtr behind;
pascal void CloseDialog(theDialog)
  DialogPtr theDialog;
pascal void DisposDialog(theDialog)
  DialogPtr theDialog;
pascal void CouldDialog(dialogID)
  short dialogID;
pascal void FreeDialog(dialogID)
  short dialogID;

/* Handling Dialog Events */

pascal void ModalDialog(filterProc,itemHit)
  ProcPtr filterProc;
  short *itemHit;
pascal Boolean IsDialogEvent(theEvent)
```

```
  struct EventRecord *theEvent;
pascal Boolean DialogSelect(theEvent,theDialog,itemHit)
  struct EventRecord *theEvent;
  DialogPtr *theDialog;
  short *itemHit;
void DlgCut(theDialog)
  DialogPtr theDialog;
void DlgCopy(theDialog)
  DialogPtr theDialog;
void DlgPaste(theDialog)
  DialogPtr theDialog;
void DlgDelete(theDialog)
  DialogPtr theDialog;
pascal void DrawDialog(theDialog)
  DialogPtr theDialog;
pascal void UpdtDialog(theDialog,updateRgn)
  DialogPtr theDialog;
  RgnHandle updateRgn;

/* Invoking Alerts */

pascal short Alert(alertID,filterProc)
  short alertID;
  ProcPtr filterProc;
pascal short StopAlert(alertID,filterProc)
  short alertID;
  ProcPtr filterProc;
pascal short NoteAlert(alertID,filterProc)
  short alertID;
  ProcPtr filterProc;
pascal short CautionAlert(alertID,filterProc)
  short alertID;
  ProcPtr filterProc;
pascal void CouldAlert(alertID)
  short alertID;
pascal void FreeAlert(alertID)
  short alertID;

/* Manipulating Items in Dialogs and Alerts */

void ParamText(param0,param1,param2,param3)
  char *param0;
  char *param1;
  char *param2;
  char *param3;
pascal void GetDItem(theDialog,itemNo,itemType,item,box)
  DialogPtr theDialog;
  short itemNo;
  short *itemType;
  Handle *item;
  Rect *box;
pascal void SetDItem(theDialog,itemNo,type,item,box)
  DialogPtr theDialog;
  short itemNo;
  short type;
  Handle item;
  Rect *box;
pascal void HideDItem(theDialog,itemNo)
  DialogPtr theDialog;
  short itemNo;
pascal void ShowDItem(theDialog,itemNo)
  DialogPtr theDialog;
  short itemNo;
int FindDItem(theDialog,thePt)
  DialogPtr theDialog;
  Point *thePt;
void GetIText(item,text)
  Handle item;
  char *text;
void SetIText(item,text)
  Handle item;
  char *text;
pascal void SelIText(theDialog,itemNo,strtSel,endSel)
  DialogPtr theDialog;
  short itemNo;
  short strtSel;
  short endSel;
short GetAlrtStage();
void ResetAlrtStage();
```

User routines

```
pascal void MyItem(theWindow,itemNo)
  WindowPtr theWindow;
  short itemNo;
pascal void MySound(soundNo)
  short soundNo;
pascal Boolean MyFilter(theDialog,theEvent,itemHit)
  DialogPtr theDialog
  struct EventRecord *theEvent;
  short *itemHit;
```

Desc iption

The Dialog Manager supports dialog boxes and the alert mechanism.

For more detailed information, see the Dialog Manager chapter of *Inside Macintosh.*

Note

`StageList` is defined as a `short`, rather than specifying the bits.

DiskInit—Disk Initialization Package

Synopsis

```
#include  <Types.h>
#include  <DiskInit.h>

/* Data Types */

typedef struct HFSDefaults {
   char    sigWord[2];  /* signature word */
   long    abSize;      /* allocation block size in bytes */
   long    clpSize;     /* clump size in bytes */
   long    nxFreeFN;    /* next free file number */
   long    btClpSize;   /* B*-Tree clump size in bytes */
   short   rsrv1;       /* reserved */
   short   rsrv2;       /* reserved */
   short   rsrv3;       /* reserved */
} HFSDefaults;

/* Routines */

void DILoad();
void DIUnload();
short DIBadMount(where,evtMessage)
   Point *where;
   long evtMessage;
OSErr DIFormat(drvNum)
   short drvNum;
OSErr DIVerify(drvNum)
   short drvNum;
OSErr DIZero(drvNum,volName)
   short drvNum;
   char *volName;
```

Description

The Disk Initialization Package found in the system-resource file initializes disks, formats the disk medium, and places appropriate file-directory structures on the disk.

For more detailed information, see the Disk Initialization Package chapter of *Inside Macintosh*.

Disks—Disk Driver

Synopsis

```
#include  <Types.h>
#include  <Disks.h>

/* Positioning Modes */

#define   fsAtMark       0   /* at current sector */
#define   fsFromStart    1   /* offset relative to beginning of file */
#define   fsFromMark     3   /* offset relative to current mark */
#define   rdVerify      64   /* added to above for read-verify */

/* Data Types */

typedef enum {sony, hard20} DriveKind;
typedef struct DrvStsSony {
   short          track;         /* current track */
   char           writeProt;     /* bit 7 = 1 if volume is locked */
   char           diskInPlace;   /* disk in place */
   char           installed;     /* drive installed */
   char           sides;         /* bit 7 = 0 if 1-sided drive */
   struct QElem   *qLink;        /* next queue entry */
   short          qType;         /* not used */
   short          dQDrive;       /* drive number */
   short          dQRefNum;      /* driver reference number */
   short          dQFSID;        /* file-system identifier */
   char           twoSideFmt;    /* -1 if 2-sided disk */
   char           needsFlush;    /* reserved */
   short          diskErrs;      /* error count */
} DrvStsSony;

typedef struct DrvStsHard20 {
   short               track;         /* current track */
   char                writeProt;     /* bit 7 = 1 if volume is locked */
   char                diskInPlace;   /* disk in place */
   char                installed;     /* drive installed */
   char                sides;         /* bit 7 = 0 if 1-sided drive */
   struct QElem *qLink;               /* next queue entry */
   short               qType;         /* not used */
   short               dQDrive;       /* drive number */
   short               dQRefNum;      /* driver reference number */
   short               dQFSID;        /* file-system identifier */
   short               DrvSize;       /* drive block size low word */
   short               DrvS1;         /* drive block size high word */
   short               DrvType;       /* 1 for Hard Disk 20 */
   short               DrvManf;       /* 1 for Apple Computer, Inc. */
   short               DrvChar;       /* 230 (0xe6) for Hard Disk 20 */
   char                DrvMisc;       /* 0--reserved */
} DrvStsHard20;
```

```
/* Routines */

OSErr DiskEject(drvNum)
   short drvNum;
OSErr SetTagBuffer(buffPtr)
   Ptr buffPtr;
OSErr DriveStatus(drvNum,status)
   short drvNum;
   DrvSts *status;
```

Description

The Disk Driver is a Macintosh device driver used for storing and retrieving information on Macintosh 3.5-inch disk drives.

For more detailed information, see the Disk Driver chapter of *Inside Macintosh*.

Errors—System Error Handler

Synopsis

```
#include  <Errors.h>

/* AppleTalk Manager Errors */

#define  sktClosedErr  (-3109)
#define  atpLenErr     (-3106)
#define  readQErr      (-3105)
#define  extractErr    (-3104)
#define  ckSumErr      (-3103)
#define  noMPPErr      (-3102)
#define  buf2SmallErr  (-3101)
#define  noRelErr      (-1101)
#define  nbpNISErr     (-1029)

/* Resource Manager Errors */

#define  mapReadErr    (-199)
#define  resAttrErr    (-198)
#define  rmvRefFailed  (-197)
#define  rmvResFailed  (-196)
#define  addRefFailed  (-195)
#define  addResFailed  (-194)
#define  resFNotFound  (-193)
#define  resNotFound   (-192)

/* File Manager Errors */

#define  fsDSIntErr    (-127)
#define  wrgVolTypErr  (-123)
#define  badMovErr     (-122)
#define  tmwdoErr      (-121)
#define  dirNFErr      (-120)

/* Memory Manager Errors */

#define  memLockedErr  (-117)  /* block is locked */
#define  memSCErr      (-116)
#define  memBCErr      (-115)
#define  memPCErr      (-114)
#define  memAZErr      (-113)
#define  memPurErr     (-112)  /* attempt to purge a locked block */
#define  memWZErr      (-111)  /* attempt to operate on a free block */
#define  memAdrErr     (-110)
#define  nilHandleErr   (109)  /* nil master pointer */
#define  memFullErr    (-108)  /* not enough room in zone */
#define  noTypeErr     (-102)  /* no data of the requested type */
#define  noScrapErr    (-100)  /* desk scrap isn't initialized  */
```

```
/* More AppleTalk Manager Errors */

#define  memROZErr       (-99)
#define  portInUse       (-97)
#define  portNotCf       (-98)
#define  excessCollsns   (-95)
#define  LAPProtErr      (-94)
#define  noBridgeErr     (-93)
#define  ddpLenErr       (-92)
#define  ddpSktErr       (-91)
#define  breakRecd       (-90)

/* Miscellaneous Errors */

#define  rcvrErr             (-89)
#define  prInitErr           (-88)  /* validity status is not 0xa8 */
#define  prWrErr             (-87)  /* parameter RAM written did not verify */
#define  clkWrErr            (-86)  /* time written did not verify */
#define  clkRdErr            (-85)  /* unable to read clock */
#define  firstDskErr         (-84)  /* first of the range of disk errors */
#define  sectNFErr           (-81)  /* can't find sector */
#define  seekErr             (-80)  /* hardware error */
#define  spdAdjErr           (-79)  /* hardware error */
#define  twoSideErr          (-78)  /* tried to read side 2 on 1-sided drive */
#define  initIWMErr          (-77)  /* hardware error */
#define  tk0BadErr           (-76)  /* hardware error */
#define  cantStepErr         (-75)  /* hardware error */
#define  cantStepErr         (-75)
#define  wrUnderrun          (-74)
#define  badDBtSlp           (-73)
#define  badDCksum           (-72)
#define  noDtaMkErr          (-71)  /* can't find data mark */
#define  badBtSlpErr         (-70)  /* bad address mark */
#define  badCksmErr          (-69)  /* bad address mark */
#define  dataVerErr          (-68)  /* read-verify failed */
#define  noAdrMkErr          (-67)  /* can't find an address mark */
#define  fontSubErr          (-66)
#define  noNybErr            (-66)  /* disk is probably blank */
#define  offLinErr           (-65)  /* no disk in drive */
#define  fontNotDeclared     (-65)
#define  fontDecError        (-64)
#define  lastDskErr          (-64)  /* last of the range of disk errors */
#define  noDriveErr          (-64)  /* drive isn't connected */
#define  wrPermErr           (-61)  /* permission does not allow writing */
#define  badMDBErr           (-60)  /* master directory block bad, reinit */
#define  fsRnErr             (-59)  /* problem during rename */
#define  extFSErr            (-58)  /* external file system */
                                    /* file-system identifier <> 0 or */
                                    /* path ref-num > 1024 */
#define  noMacDskErr         (-57)  /* volume lacks Mac-format directory */
#define  nsDrvErr            (-56)  /* no such drive in the drive queue */
#define  volOnLinErr         (-55)  /* volume already mounted and on-line */
#define  permErr             (-54)  /* permission doesn't allow writing */
#define  volOffLinErr        (-53)  /* volume not on-line */
```

```
#define  gfpErr             (-52)
#define  rfNumErr           (-51)  /* bad reference number */
#define  paramErr           (-50)

/* File Manager Errors */

#define  opWrErr        (-49) /* only one writer allowed */
#define  dupFNErr       (-48) /* file by that name already exists */
#define  fBsyErr        (-47) /* one or more files are open */
#define  vLckdErr       (-46) /* volume locked by software flag */
#define  fLckdErr       (-45) /* file locked */
#define  wPrErr         (-44) /* volume locked by hardware setting */
#define  fnfErr         (-43) /* file not found */
#define  tmfoErr        (-42) /* only 12 files can be open at once */
#define  posErr         (-40) /* attempted to position before start */
#define  eofErr         (-39) /* logical EOF reached during read */
#define  fnOpnErr       (-38) /* file not open */
#define  bdNamErr       (-37) /* bad filename or volume name--zero*/
                              /* length? */
#define  ioErr          (-36) /* disk I/O error */
#define  nsvErr         (-35) /* specified volume doesn't exist */
#define  dskFulErr      (-34) /* all allocation blocks are full */
#define  dirFulErr      (-33) /* file directory full */
#define  notOpenErr     (-28) /* driver isn't open */
#define  abortErr       (-27) /* I/O request aborted by KillIO */
#define  dInstErr       (-26) /* couldn't find driver in resource file */
#define  dRemoveErr     (-25) /* tried to remove an open driver */
#define  closeErr       (-24)
#define  openErr        (-23) /* requested r/w permission refused */
#define  unitEmptyErr   (-22) /* reference number specifies nil handle */
#define  badUnitErr     (-21) /* refNum doesn't match unit table */
#define  writErr        (-20) /* driver can't respond to Write calls */
#define  readErr        (-19) /* driver can't respond to Read calls */
#define  statusErr      (-18) /* driver can't respond to Status call */
#define  controlErr     (-17) /* driver can't respond to this call */

/* More Miscellaneous Errors */

#define  SENoDB          (-8)
#define  unimpErr        (-4)
#define  corErr          (-3)
#define  vTypErr         (-2)   /* qType field isn't vType */
#define  qErr            (-1)   /* element not in specified queue */
#define  noErr             0    /* no error */
#define  dsBusErr          1    /* bus Error */
#define  evtNotEnb         1
#define  swOverrunErr      1    /* set if software overrun error */
#define  scCommErr         2    /* breakdown in SCSI protocols: */
#define  dsAddressErr      2    /* address error */
#define  dsIllInstErr      3    /* illegal instruction */
#define  dsZeroDivErr      4    /* zero divide */
#define  scBadParmsErr     4    /* unrecognized instruction in TIB */
#define  scPhaseErr        5
```

```
#define  dsChkErr          5  /* check exception */
#define  dsOvflowErr       6  /* TrapV exception */
#define  scCompareErr      6  /* data comparison during read */
#define  dsPrivErr         7  /* privilege violation */
#define  dsTraceErr        8  /* trace exception */
#define  dsLineAErr        9  /* line 1010 exception */
#define  dsLineFErr       10  /* line 1111 exception */
#define  dsMiscErr        11  /* miscellaneous exception */
#define  dsCoreErr        12  /* unimplemented core routine*/
#define  dsIrqErr         13  /* spurious interrupt */
#define  dsIOCoreErr      14  /* I/O system error */
#define  dsLoadErr        15  /* segment loader error */
#define  dsFPErr          16  /* floating-point error */
#define  parityErr        16  /* set if parity error */
#define  dsNoPackErr      17  /* can't load package 0 */
#define  dsMemFullErr     25  /* out of memory */
#define  dsFSErr          27  /* file map trashed */
#define  dsStknHeap       28
#define  dsReinsert       30
#define  dsNotThe1        31

/* More Miscellaneous Errors */

#define  menuPrgErr       84
#define  hwOverrunErr     32  /* set if hardware overrun error */
#define  framingErr       64  /* set if framing error */
#define  dsSysErr      32767  /* system error */
         void SysError(errorCode)
            short errorCode;
```

Description The System Error Handler is the part of the Macintosh Operating System that assumes control when a fatal error occurs.

For more detailed information, see the System Error Handler chapter of *Inside Macintosh*.

Events—Toolbox Event Manager

Synopsis

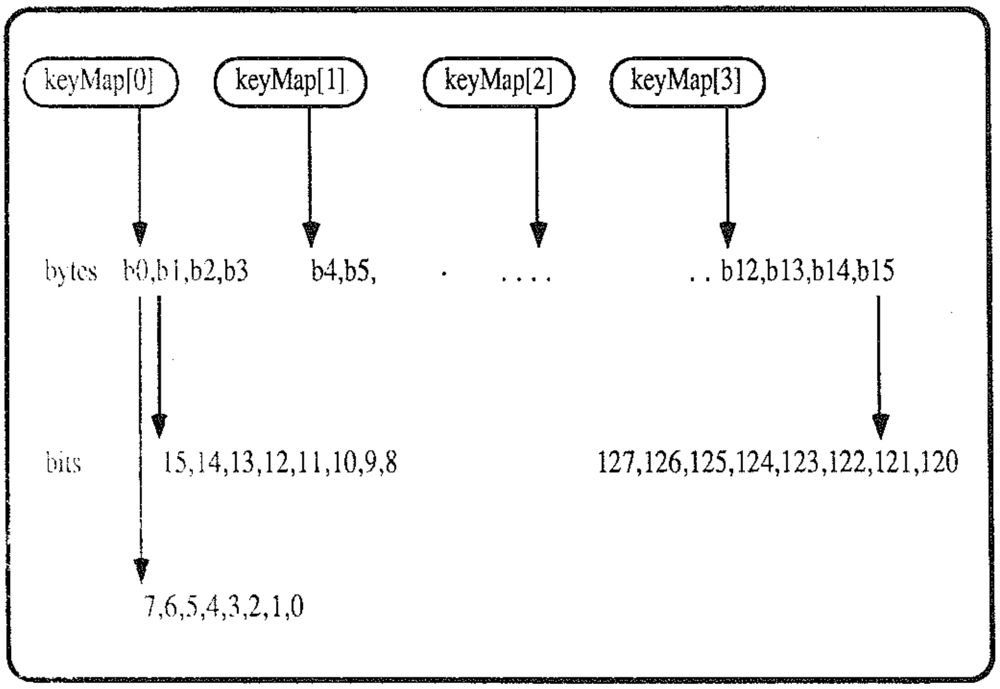
```
#include  <Types.h>
#include  <Events.h>

/* Event Codes */

#define   nullEvent     0
#define   mouseDown     1
#define   mouseUp       2
#define   keyDown       3
#define   keyUp         4
#define   autoKey       5
#define   updateEvt     6
#define   diskEvt       7
#define   activateEvt   8
#define   networkEvt   10
#define   driverEvt    11
#define   app1Evt      12
#define   app2Evt      13
#define   app3Evt      14
#define   app4Evt      15

/* Masks for Keyboard Event Message */

#define   charCodeMask   0x000000FF
#define   keyCodeMask    0x0000FF00

/* Masks for Forming Event Mask */

#define   mDownMask           2
#define   mUpMask             4
#define   keyDownMask         8
#define   keyUpMask          16
#define   autoKeyMask        32
#define   updateMask         64
#define   diskMask          128
#define   activMask         256
#define   networkMask      1024
#define   driverMask       2048
#define   app1Mask         4096
#define   app2Mask         8192
#define   app3Mask        16384
#define   app4Mask      (-32768)
#define   everyEvent       (-1)

/* Modifier Flags in Event Record */

#define   activeFlag     1
```

```
#define   btnState     128
#define   cmdKey       256
#define   shiftKey     512
#define   alphaLock   1024
#define   optionKey   2048

/* Data Types */

typedef struct EventRecord {
   short                  what;
   long                   message;
   long                   when;
   Point                  where;
   short                  modifiers;
} EventRecord;

typedef long KeyMap[4];

/* Accessing Events */

pascal Boolean GetNextEvent(eventMask,theEvent)
   short eventMask;
   EventRecord *theEvent;
pascal Boolean EventAvail(eventMask,theEvent)
   short eventMask;
   EventRecord *theEvent;

/* Reading the Mouse */

pascal void GetMouse(mouseLoc)
   Point *mouseLoc;
pascal Boolean Button();
pascal Boolean StillDown();
pascal Boolean WaitMouseUp();

/* Reading the Keyboard and Keypad */

pascal void GetKeys(theKeys)
   KeyMap theKeys;

/* Miscellaneous Routines */

pascal long TickCount();
long GetDblTime();
long GetCaretTime();
```

Description The Toolbox Event Manager provides access to the Macintosh keyboard, keypad, and mouse. The keyboard bit map returned by the function `GetKeys()` is organized as shown in Figure 4-1. The bits aren't numbered as you might expect. Here is the actual numbering scheme, corresponding to the key code numbers given in the figure "Key Codes" in the Toolbox Event Manager chapter of *Inside Macintosh*.

Figure 4-1
The keyboard bit map

Figure 4-1. **The Keyboard Bit Map**



For more detailed information, see the Toolbox Event Manager chapter of *Inside Macintosh*.

Files—File Manager

Synopsis

```
#include  <Types.h>
#include  <OSUtils.h>
#include  <Files.h>

/* Flags in File Information Used by the Finder */

#define   fOnDesk         1   /* set if file is on desktop (HFS only) */
#define   fHasBundle   8192   /* set if file has a bundle */
#define   fInvisible  16384   /* set if file's icon is invisible */
#define   fTrash        (-3)  /* file is in trash window */
#define   fDesktop      (-2)  /* file is on desktop */
#define   fDisk           0   /* file is in disk window */

/* Values for Requesting Read/Write Permission */

#define   fsCurPerm     0   /* whatever is currently allowed */
#define   fsRdPerm      1   /* request to read only */
#define   fsWrPerm      2   /* request to write only */
#define   fsRdWrPerm    3   /* request to read and write */
#define   fsRdWrShPerm  4   /* request shared read and write */

/* Positioning Modes */

#define   fsAtMark          0   /* at current position of mark */
                                /*  (posOff or ioPosOffset ignored) */
#define   fsFromStart       1   /* offset relative to beginning of file */
#define   fsFromLEOF        2   /* offset relative to logical EOF */
#define   fsFromMark        3   /* offset relative to current mark */
#define   rdVerify         64   /* added to above for read-verify */
#define ioDirFlg            4
#define ioDirMask     (1 << 4)
#define fsRtParID           1
#define fsRtDirID           2

/* Data Types */

typedef struct FInfo {
  OSType  fdType;     /* the type of the file */
  OSType  fdCreator;  /* file's creator */
  short   fdFlags;    /* flags: hasBundle, invisible, etc. */
  Point   fdLocation; /* file's location in window */
  short   fdFldr;     /* folder containing file */
} FInfo;

typedef struct FXInfo {
  short                 ffIconID;       /* Icon ID */
  short                 ffUnused[4];    /* reserved */
```

```
   short                 ffComment;       /* comment ID */
   long                  ffPutAway;       /* home directory ID */
} FXInfo ;

typedef struct DInfo {
   Rect                  frRect;          /* folder's rectangle */
   unsigned short        frFlags;         /* flags */
   Point                 frLocation;      /* folder's location */
   short                 frView;          /* folder's view */
} DInfo;

typedef struct DXInfo {
   Point                 frScroll;        /* scroll position */
   long                  frOpenChain;     /* directory ID chain of open folders */
   short                 frUnused;        /* reserved */
   short                 frComment;       /* comment ID */
   long                  frPutAway;       /* directory ID */
} DXInfo;

typedef struct IOParam {
   struct QElem *qLink;                   /* next queue entry */
   short                 qType;           /* queue type */
   short                 ioTrap;          /* routine trap */
   Ptr                   ioCmdAddr;       /* routine address */
   ProcPtr               ioCompletion;    /* completion routine */
   OSErr                 ioResult;        /* result code */
   StringPtr             ioNamePtr;       /* pathname */
   short                 ioVRefNum;       /* volume refnum or drive number */
   short                 ioRefNum;        /* path reference number */
   char                  ioVersNum;       /* version number */
   char                  ioPermssn;       /* read/write permission */
   Ptr                   ioMisc;          /* miscellaneous (use for PBSetFVers) */
   Ptr                   ioBuffer;        /* data buffer */
   long                  ioReqCount;      /* requested number of bytes */
   long                  ioActCount;      /* actual byte count completed */
   short                 ioPosMode;       /* newline char and type of
                                          /* positioning */
   long                  ioPosOffset;     /* size of positioning offset */
} IOParam;

typedef struct FileParam {
   struct QElem *qLink;                   /* next queue entry */
   short                 qType;           /* queue type */
   short                 ioTrap;          /* routine trap */
   Ptr                   ioCmdAddr;       /* routine address */
   ProcPtr               ioCompletion;    /* completion routine */
   OSErr                 ioResult;        /* result code */
   StringPtr             ioNamePtr;       /* pathname */
   short                 ioVRefNum;       /* volume refnum or drive number */
   short                 ioFRefNum;       /* path reference number */
   char                  ioFVersNum;      /* version number */
   char                  filler1;         /* not used */
   short                 ioFDirIndex;     /* sequence number of file */
```

```
    unsigned char        ioFlAttrib;      /* file attributes */
    unsigned char        ioFlVersNum;     /* version number */
    FInfo                ioFlFndrInfo;    /* information used by the Finder */
    unsigned long        ioFlNum;         /* file number */
    unsigned short       ioFlStBlk;       /* first block of data fork */
    long                 ioFlLgLen;       /* logical EOF of data fork */
    long                 ioFlPyLen;       /* physical EOF of data fork */
    unsigned short       ioFlRStBlk;      /* first block of resource fork */
    long                 ioFlRLgLen;      /* logical EOF of resource fork */
    long                 ioFlRPyLen;      /* physical EOF of resource fork */
    unsigned long        ioFlCrDat;       /* date and time of creation */
    unsigned long        ioFlMdDat;       /* date and time of last modification */
} FileParam;

typedef struct VolumeParam {
    struct QElem *qLink;                  /* next queue entry */
    short                qType;           /* queue type */
    short                ioTrap;          /* routine trap */
    Ptr                  ioCmdAddr;       /* routine address */
    ProcPtr              ioCompletion;    /* completion routine */
    OSErr                ioResult;        /* result code */
    StringPtr            ioNamePtr;       /* pathname */
    short                ioVRefNum;       /* volume refnum or drive number */
    long                 filler2;         /* not used */
    short                ioVolIndex;      /* volume index */
    unsigned long        ioVCrDate;       /* date and time of initialization */
    unsigned long        ioVLsBkUp;       /* date and time of last volume backup */
    unsigned short       ioVAtrb;         /* bit 15=1 if volume locked */
    unsigned short       ioVNmFls;        /* number of files in file directory */
    unsigned short       ioVDirSt;        /* first block of file directory */
    short                ioVBlLn;         /* number of blocks in file directory */
    unsigned short       ioVNmAlBlks;     /* number of alloc blocks on volume */
    long                 ioVAlBlkSiz;     /* number of bytes per alloc block */
    long                 ioVClpSiz;       /* number of bytes to allocate */
    unsigned short       ioAlBlSt;        /* first block in volume block map */
    unsigned long        ioVNxtFNum;      /* next free file number */
    unsigned short       ioVFrBlk;        /* number of free allocation blocks */
} VolumeParam;

typedef struct HIOParam {
    struct QElem *qLink;                  /* next queue entry */
    short                qType;           /* queue type */
    short                ioTrap;          /* routine trap */
    Ptr                  ioCmdAddr;       /* routine address */
    ProcPtr              ioCompletion;    /* completion routine */
    OSErr                ioResult;        /* result code */
    StringPtr            ioNamePtr;       /* pathname */
    short                ioVRefNum;       /* volume refnum or drive number */
    short                ioRefNum;        /* path reference number */
    char                 ioVersNum;       /* version number */
    char                 ioPermssn;       /* read/write permission */
    Ptr                  ioMisc;          /* miscellaneous (use high byte for */
                                          /* PBSetFVers) */
    Ptr                  ioBuffer;        /* data buffer */
    long                ioReqCount;      /* requested number of bytes */
    long                ioActCount;      /* actual byte count completed */
    short               ioPosMode;       /* newline char and type of positioning */
    long                ioPosOffset;     /* size of positioning offset */
    short               filler1;         /* empty field */
} HIOParam;

typedef union ParamBlockRec {
    struct IOParam ioParam;
    struct FileParam fileParam;
    struct VolumeParam volumeParam;
} ParamBlockRec, *ParmBlkPtr;

typedef struct HFileParam {
    struct QElem *qLink;                 /* next queue entry */
    short               qType;           /* queue type */
    short               ioTrap;          /* routine trap */
    Ptr                 ioCmdAddr;       /* routine address */
    ProcPtr             ioCompletion;    /* completion routine */
    OSErr               ioResult;        /* result code */
    StringPtr           ioNamePtr;       /* pathname */
    short               ioVRefNum;       /* volume refnum or drive number */
    short               ioFRefNum;       /* path reference number */
    char                ioFVersNum;      /* version number */
    char                filler1;         /* not used */
    short               ioFDirIndex;     /* sequence number of file */
    char                ioFlAttrib;      /* file attributes */
    char                ioFlVersNum;     /* version number */
    FInfo               ioFlFndrInfo;    /* information used by the Finder */
    long                ioDirID;         /* directory ID */
    unsigned short      ioFlStBlk;       /* first block of data fork */
    long                ioFlLgLen;       /* logical EOF of data fork */
    long                ioFlPyLen;       /* physical EOF of data fork */
    unsigned short      ioFlRStBlk;      /* first block of resource fork */
    long                ioFlRLgLen;      /* logical EOF of resource fork */
    long                ioFlRPyLen;      /* physical EOF of resource fork */
    unsigned long       ioFlCrDat;       /* date and time of creation */
    unsigned long       ioFlMdDat;       /* date and time of last modification */
} HFileParam;

typedef struct HVolumeParam {
    struct QElem *qLink;                 /* next queue entry */
    short               qType;           /* queue type */
    short               ioTrap;          /* routine trap */
    Ptr                 ioCmdAddr;       /* routine address */
    ProcPtr             ioCompletion;    /* completion routine */
    OSErr               ioResult;        /* result code */
    StringPtr           ioNamePtr;       /* pathname */
    short               ioVRefNum;       /* volume refnum or drive number */
    long                filler2;         /* not used */
    short               ioVolIndex;      /* volume index */
    unsigned long       ioVCrDate;       /* date and time of initialization */
    unsigned long       ioVLsMod;        /* date and time of last modification */
    unsigned short      ioVAtrb;         /* volume attributes */
```

```
  unsigned short        ioVNmFls;        /* number of files in file directory */
  short                 ioVBitMap;       /* first block of volume bitmap */
  short                 ioAllocPtr;      /* used internally */
  unsigned short        ioVNmAlBlks;     /* number of alloc blocks on volume */
  long                  ioVAlBlkSiz;     /* number of bytes per alloc block */
  long                  ioVClpSiz;       /* number of bytes to Allocate */
  short                 ioAlBlSt;        /* first block in volume block map */
  long                  ioVNxtCNID;      /* next unused node ID */
  unsigned short        ioVFrBlk;        /* number of free allocation blocks */
  unsigned short        ioVSigWord;      /* volume signature */
  short                 ioVDrvInfo;      /* drive number */
  short                 ioVDRefNum;      /* driver reference number */
  short                 ioVFSID;         /* file-system identifier */
  unsigned long         ioVBkUp;         /* date and time of last backup */
  unsigned short        ioVSeqNum;       /* used internally */
  long                  ioVWrCnt;        /* volume write count */
  long                  ioVFilCnt;       /* number of files on volume */
  long                  ioVDirCnt;       /* number of directories on volume */
  long                  ioVFndrInfo[8];  /* info used by the Finder */
}HVolumeParam;

typedef union HParamBlockRec {
  struct HIOParam ioParam;
  struct HFileParam fileParam;
  struct HVolumeParam volumeParam;
} HParamBlockRec, *HParmBlkPtr;

typedef enum {hfileInfo,dirInfo} CInfoType;

typedef struct HFileInfo {
  struct QElem *qLink;                   /* next queue entry */
  short                 qType;           /* queue type */
  short                 ioTrap;          /* routine trap */
  Ptr                   ioCmdAddr;       /* routine address */
  ProcPtr               ioCompletion;    /* completion routine */
  OSErr                 ioResult;        /* result code */
  StringPtr             ioNamePtr;       /* pathname */
  short                 ioVRefNum;       /* volume refnum or drive number */
  short                 ioFRefNum;       /* path reference number */
  char                  ioFVersNum;      /* version number */
  char                  filler1;         /* not used */
  short                 ioFDirIndex;     /* sequence number of file */
  char                  ioFlAttrib;      /* file attributes */
  char                  filler2;         /* not used */
  FInfo                 ioFlFndrInfo;    /* information used by the Finder */
  long                  ioDirID;         /* file number */
  unsigned short        ioFlStBlk;       /* first block of data fork */
  long                  ioFlLgLen;       /* logical EOF of data fork */
  long                  ioFlPyLen;       /* physical EOF of data fork */
  unsigned short        ioFlRStBlk;      /* first block of resource fork */
  long                  ioFlRLgLen;      /* logical EOF of resource fork */
  long                  ioFlRPyLen;      /* physical EOF of resource fork */
  unsigned long         ioFlCrDat;       /* date and time of creation */
  unsigned long         ioFlMdDat;       /* date and time of last modification */
  unsigned long        ioFlBkDat;        /* date and time of last backup */
  FXInfo               ioFlXFndrInfo;    /* additional info for Finder */
  long                 ioFlParID;        /* file's parent directory ID */
  long                 ioFlClpSiz;       /* file's clump size */
} HFileInfo;

typedef struct DirInfo {
  struct QElem *qLink;                   /* next queue entry */
  short                qType;            /* queue type */
  short                ioTrap;           /* routine trap */
  Ptr                  ioCmdAddr;        /* routine address */
  ProcPtr              ioCompletion;     /* completion routine */
  OSErr                ioResult;         /* result code */
  StringPtr            ioNamePtr;        /* pathname */
  short                ioVRefNum;        /* volume refnum or drive number */
  short                ioFRefNum;        /* path reference number */
  char                 ioFVersNum;       /* version number */
  char                 filler1;          /* not used */
  short                ioFDirIndex;      /* sequence number of file */
  char                 ioFlAttrib;       /* file attributes */
  char                 filler2;          /* not used */
  DInfo                ioDrUsrWds;       /* information used by the Finder */
  long                 ioDrDirID;        /* directory ID */
  unsigned short       ioDrNmFls;        /* number of files in directory */
  short                filler3[9];       /* not used */
  unsigned long        ioDrCrDat;        /* date and time of creation */
  unsigned long        ioDrMdDat;        /* date and time of last modification */
  unsigned long        ioDrBkDat;        /* date and time of last backup */
  DXInfo               ioDrFndrInfo;     /* additional info for Finter */
  long                 ioDrParID;        /* file's parent directory ID */
} DirInfo;

typedef union CInfoPBRec {
  HFileInfo hfileInfo;
  DirInfo dirInfo;
} CInfoPBRec;

typedef struct CMovePBRec {
  struct QElem *qLink;                   /* next queue entry */
  short                qType;            /* queue type */
  short                ioTrap;           /* routine trap */
  Ptr                  ioCmdAddr;        /* routine address */
  ProcPtr              ioCompletion;     /* completion routine */
  OSErr                ioResult;         /* result code */
  StringPtr            ioNamePtr;        /* pathname */
  short                ioVRefNum;        /* volume refnum or drive number */
  long                 filler1;          /* not used */
  StringPtr            ioNewName;        /* name of new directory */
  long                 filler2;
  long                 ioNewDirID;       /* directory ID of new directory */
  long                 filler3[2];
  long                 ioDirID;          /* directory ID of current directory */
} CMovePBRec, *CMovePBPtr;
```

```
typedef enum {hfileInfo, dirInfo} CInfoType;

typedef struct WDPBRec {
  struct QElem *qLink;                    /* next queue entry */
  short               qType;              /* queue type */
  short               ioTrap;             /* routine trap */
  Ptr                 ioCmdAddr;          /* routine address */
  ProcPtr             ioCompletion;       /* completion routine */
  OSErr               ioResult;           /* result code */
  StringPtr           ioNamePtr;          /* pathname */
  short               ioVRefNum;          /* volume refnum or drive number */
  short               filler1;            /* not used */
  short               ioWDIndex;          /* working directory index */
  long                ioWDProcID;         /* working directory user identifier */
  short               ioWDVRefNum;        /* working directory's volume ref number */
  short               filler2[7];
  long                ioWDDirID;          /* working directory's directory ID */
} WDPBRec, *WDPBPtr;

typedef struct FCBPBRec {
  struct QElem *qLink;                    /* next queue entry */
  short               qType;              /* queue type */
  short               ioTrap;             /* routine trap */
  Ptr                 ioCmdAddr;          /* routine address */
  ProcPtr             ioCompletion;       /* completion routine */
  OSErr               ioResult;           /* result code */
  StringPtr           ioNamePtr;          /* pathname */
  short               ioVRefNum;          /* volume refnum or drive number */
  short               ioRefNum;           /* path reference number */
  short               filler;
  short               filler1;            /* FCB index */
  long                ioFCBFlNm;          /* file number */
  short               ioFCBFlags;
  unsigned short      ioFCBStBlk;         /* first allocation block of file */
  long                ioFCBEOF;           /* logical EOF */
  long                ioFCBPLen;          /* physical EOF */
  long                ioFCBCrPs;          /* mark */
  short               ioFCBVRefNum;       /* volume reference number */
  long                ioFCBClpSiz;        /* file's clump size */
  long                ioFCBParID;         /* parent directory ID */
} FCBPBRec,*FCBPBPtr;

typedef struct VCB {
  struct QElem *qLink;                    /* next queue entry */
  short               qType;              /* not used */
  short               vcbFlags;           /* bit 15=1 if dirty */
  unsigned short      vcbSigWord;         /* always 0xd2d7 */
  unsigned long       vcbCrDate;          /* date volume was initialized */
  unsigned long       vcbLsMod;           /* date of last backup */
  short               vcbAtrb;            /* volume attributes */
  unsigned short      vcbNmFls;           /* number of files in directory */
  short               vcbVBMSt;           /* directory's first block */
  short               vcbAllocPtr;        /* length of file directory */
  unsigned short      vcbNmAlBlks;        /* number of allocation blocks */
  long               vcbAlBlkSiz;    /* size of allocation blocks */
  long               vcbClpSiz;      /* number of bytes to Allocate */
  short              vcbAlBlSt;      /* first block in block map */
  long               vcbNxtCNID;     /* next unused file number */
  unsigned short     vcbFreeBks;     /* number of unused blocks */
  String(27)         vcbVN;          /* volume name */
  short              vcbDrvNum;      /* drive number */
  short              vcbDRefNum;     /* driver reference number */
  short              vcbFSID;        /* file-system identifier */
  short              vcbVRefNum;     /* volume reference number */
  Ptr                vcbMAdr;        /* location of block map */
  Ptr                vcbBufAdr;      /* location of volume buffer */
  short              vcbMLen;        /* number of bytes in block map */
  short              vcbDirIndex;    /* used internally */
  short              vcbDirBlk;      /* used internally */
  unsigned long      vcbVolBkUp;     /* date and time of last backup */
  unsigned short     vcbVSeqNum;     /* used internally */
  long               vcbWrCnt;       /* volume write count */
  long               vcbXTClpSiz;    /* clump size of extents tree file */
  long               vcbCTClpSiz;    /* clump size of catalog tree file */
  unsigned short     vcbNmRtDirs;    /* number of directories in root */
  long               vcbFilCnt;      /* number of files on volume */
  long               vcbDirCnt;      /* number of directories on volume */
  long               vcbFndrInfo[8]; /* used by Finder */
  unsigned short     vcbVCSize;      /* used internally */
  unsigned short     vcbVBMCSiz;     /* used internally */
  unsigned short     vcbCtlCSiz;     /* used internally */
  unsigned short     vcbXTAlBlks;    /* size in blocks of extents tree file */
  unsigned short     vcbCTAlBlks;    /* size in blocks of catalog tree file */
  short              vcbXTRef;       /* path reference number for extents */
                                     /* tree file */
  short              vcbCTRef;       /* path ref number of catalog tree file */
  Ptr                vcbCtlBuf;      /* pointer to extents and catalog caches */
  long               vcbDirIDM;      /* directory last searched */
  short              vcbOffsM;       /* offspring index at last search */
} VCB;

typedef struct DrvQEl {
  struct QElem *qLink;                /* next queue entry */
  short              qType;           /* queue type */
  short              dQDrive;         /* drive number */
  short              dQRefNum;        /* drive reference number */
  short              dQFSID;          /* file system identifier */
  unsigned short     dQDrvSz;         /* number of logical blocks */
  unsigned short     dQDrvSz2;
} DrvQEl, *DrvQElPtr;

/* --- High-Level Routines ------------------------------------------ */

/* Accessing Volumes */

OSErr GetVInfo(drvNum,volName,vRefNum,freeBytes)
   short drvNum;
   char *volName;
   short *vRefNum;
   long *freeBytes;
OSErr GetVRefNum(pathRefNum,vRefNum)
   short pathRefNum;
   short *vRefNum;
OSErr GetVol(volName,vRefNum)
   char *volName;
   short *vRefNum;
OSErr SetVol(volName,vRefNum)
   char *volName;
   short vRefNum;
OSErr FlushVol(volName,vRefNum)
   char *volName;
   short vRefNum;
OSErr UnmountVol(volName,vRefNum)
   char *volName;
   short vRefNum;
OSErr Eject(volName,vRefNum)
   char *volName;
   short vRefNum;

/* Changing File Contents */

OSErr FSOpen(fileName,vRefNum,refNum)
   char *fileName;
   short vRefNum;
   short *refNum;
OSErr OpenRF(fileName,vRefNum,refNum)
   char *fileName;
   short vRefNum;
   short *refNum;
OSErr FSRead(refNum,count,buffPtr)
   short refNum;
   long *count;
   Ptr buffPtr;
OSErr FSWrite(refNum,count,buffPtr)
   short refNum;
   long *count;
   Ptr buffPtr;
OSErr GetFPos(refNum,filePos)
   short refNum;
   long *filePos;
OSErr SetFPos(refNum,posMode,posOff)
   short refNum;
   short posMode;
   long posOff;
OSErr GetEOF(refNum,logEOF)
   short refNum;
   long *logEOF;
OSErr SetEOF(refNum,logEOF)
   short refNum;
   long logEOF;
OSErr Allocate(refNum,count)
```

```
   short refNum;
   long *count;
OSErr FSClose(refNum)
   short refNum;

/* Creating and Deleting Files */

OSErr Create(fileName,vRefNum,creator,fileType)
   char *fileName;
   short vRefNum;
   OSType creator;
   OSType fileType;
OSErr FSDelete(fileName,vRefNum)
   char *fileName;
   short vRefNum;

/* Changing Information About Files */

OSErr GetFInfo(fileName,vRefNum,fndrInfo)
   char *fileName;
   short vRefNum;
   FInfo *fndrInfo;
OSErr SetFInfo(fileName,vRefNum,fndrInfo)
   char *fileName;
   short vRefNum;
   FInfo *fndrInfo;
OSErr SetFLock(fileName,vRefNum)
   char *fileName;
   short vRefNum;
OSErr RstFLock(fileName,vRefNum)
   char *fileName;
   short vRefNum;
OSErr Rename(oldName,vRefNum,newName)
   char *oldName;
   short vRefNum;
   char *newName;

/* --- Low-Level Routines ------------------------------------------- */

/* Initializing the File I/O Queue */

void FInitQueue();
void AddDrive(drvrRefNum,drvNum,qEl);
   short drvrRefNum,drvNum;
   DrvQElPtr qEl;
OSErr PBMountVol(paramBlock)
   ParamBlockRec *paramBlock;

/* Accessing Volumes */

OSErr PBGetVInfo(paramBlock,async)
   ParamBlockRec *paramBlock;
```

```
  Boolean async;
OSErr PBHGetVInfo(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBSetVInfo(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBGetVol(paramBlock,async)
  WDPBPtr paramBlock;
  Boolean async;
OSErr PBHGetVol(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBSetVol(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHSetVol(paramBlock,async)
  WDPBPtr paramBlock;
  Boolean async;
OSErr PBFlushVol(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBUnmountVol(paramBlock)
  ParamBlockRec *paramBlock;
OSErr PBOffLine(paramBlock)
  ParamBlockRec *paramBlock;
OSErr PBEject(paramBlock)
  ParamBlockRec *paramBlock;

/* Accessing Files */

OSErr PBOpen(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHOpen(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBOpenRF(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHOpenRF(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBLockRange(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBUnlockRange(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBRead(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBWrite(paramBlock,async)
  ParamBlockRec *paramBlock;
```

```
   Boolean async;
OSErr PBGetFPos(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBSetFPos(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBGetEOF(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBSetEOF(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBAllocate(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBAllocContig(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBFlushFile(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBClose(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;

/* Creating and Deleting Files and Directories */

OSErr PBCreate(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBHCreate(paramBlock,async)
   HParamBlockRec *paramBlock;
   Boolean async;
OSErr PBDirCreate(paramBlock,async)
   HParamBlockRec *paramBlock;
   Boolean async;
OSErr PBDelete(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBHDelete(paramBlock,async)
   HParamBlockRec *paramBlock;
   Boolean async;

/* Changing Information About Files and Directories */

OSErr PBGetFInfo(paramBlock,async)
   ParamBlockRec *paramBlock;
   Boolean async;
OSErr PBHGetFInfo(paramBlock,async)
   HParamBlockRec *paramBlock;
   Boolean async;
OSErr PBSetFInfo(paramBlock,async)
```

```
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHSetFInfo(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBSetFLock(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHSetFLock(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBRstFLock(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHRstFLock(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;
OSErr PBSetFVers(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBRename(paramBlock,async)
  ParamBlockRec *paramBlock;
  Boolean async;
OSErr PBHRename(paramBlock,async)
  HParamBlockRec *paramBlock;
  Boolean async;

/* Hierarchical-Only Routines */

OSErr PBGetCatInfo(paramBlock,async)
  CInfoPBRec *paramBlock;
  Boolean async;
OSErr PBSetCatInfo(paramBlock,async)
  CInfoPBRec *paramBlock;
  Boolean async;
OSErr PBCatMove(paramBlock,async)
  CMovePBPtr *paramBlock;
  Boolean async;
OSErr PBOpenWD(paramBlock,async)
  WDPBPtr *paramBlock;
  Boolean async;
OSErr PBCloseWD(paramBlock,async)
  WDPBPtr *paramBlock;
  Boolean async;
OSErr PBGetWDInfo(paramBlock,async)
  WDPBPtr *paramBlock;
  Boolean async;

/* Advanced Routines */

struct QHdr *GetFSQHdr();
struct QHdr *GetVCBQHdr();
struct QHdr *GetDrvQHdr();
```

```
OSErr PBGetFCBInfo(paramBlock,async)
   FCBPBRec *paramBlock;
   Boolean async;
```

Description

The File Manager controls the exchange of information between an application and files.

For more detailed information, see the File Manager chapter of *Inside Macintosh*.

Notes

Because the global data pointer (register A5) may not be valid at the time an I/O completion routine is executing, that routine cannot safely access any global variables or strings, nor can it call functions outside its segment.

Because C does not have variant records like Pascal, some Pascal records in *Inside Macintosh* are represented by more than one C `typedef` in this interface.

Warning

The low-level routines that use strings take as input and return as output pointers to Pascal-style strings (string length in first byte). However, the high-level routines use C-style strings (terminated by a null character) as input and output parameters.

FixMath—fixed-point math

Synopsis

```
#include <Types.h>
#include <FixMath.h>

/* Routines Available in RAM Library for 64K ROM Users */
/*   and in 128K ROM */

/* Arithmetic Operations */

pascal Fixed FixDiv(x,y)
  Fixed x,y;
pascal Fract FracDiv(x,y)
  Fract x,y;
pascal Fract FracMul(x,y)
  Fract x,y;
pascal Fract FracSqrt(x)
  Fract x;
pascal Fract FracSin(x)
  Fixed x;
pascal Fract FracCos(x)
  Fixed x;

/* Routines Available Only in New Macintosh Plus (128K) ROM */

pascal Fixed FixATan2(x,y)
  long x,y;

/* Conversion Functions */

pascal Fixed Long2Fix(x)
  long x;
pascal long Fix2Long(x)
  Fixed x;
pascal Fract Fix2Frac(x)
  Fixed x;
pascal Fixed Frac2Fix(x)
  Fract x;
pascal extended Fix2X(x)
  Fixed x;
Fixed X2Fix(x)
  extended x;
pascal extended Frac2X(x)
  Fract x;
Fract X2Frac(x)
  extended x;
```

Description The FixMath library provides new fixed-point arithmetic routines in addition to those provided by the ToolUtils library.

For more detailed information about the new fixed-point math routines, see the Toolbox Utilities chapter of *Inside Macintosh,* Volume 4.

Fonts—Font Manager

Synopsis

```
#include <Types.h>
#include <Fonts.h>

/* Font Numbers */

#define systemFont       0
#define applFont         1
#define newYork          2
#define geneva           3
#define monaco           4
#define venice           5
#define london           6
#define athens           7
#define sanFran          8
#define toronto          9
#define cairo           11
#define losAngeles      12
#define times           20
#define helvetica       21
#define courier         22
#define symbol          23
#define mobile          24

/* Special Characters */

#define commandMark  '\021'
#define checkMark    '\022'
#define diamondMark  '\023'
#define appleMark    '\024'

/* Font Types */

#define propFont     0x9000
#define prpFntH      0x9001
#define prpFntW      0x9002
#define prpFntHW     0x9003
#define fixedFont    0xB000
#define fxdFntH      0xB001
#define fxdFntW      0xB002
#define fxdFntHW     0xB003
#define fontWid      0xACB0

typedef struct FMInput {
  short                 family;        /* for example, New York */
  short                 size;          /* for example, 12 Point */
  Style                 face;          /* for example, bold or underline */
  Boolean               needBits;      /* bits or just measurement */
  short                  device;        /* always 0 for display */
  Point                  numer;         /* current drawing scale */
  Point                  denom;         /* current drawing scale */
} FMInput;

typedef struct FMOutput {
  short                  errNum;        /* not used */
  Handle                 fontHandle;    /* Handle to font */
  unsigned char          boldPixels;    /* pixels of horizontal smear */
  unsigned char          italicPixels;  /* pixels of horizontal smear */
  unsigned char          ulOffset;      /* pixels below baseline */
  unsigned char          ulShadow;      /* pixels in halo */
  unsigned char          ulThick;       /* thickness of underline */
  unsigned char          shadowPixels;  /* pixels to shadow (0..3) */
  char                   extra;         /* extra white pixels/char */
  unsigned char          ascent;        /* ascent */
  unsigned char          descent;       /* descent */
  unsigned char          widMax;        /* maximum character width */
  char                   leading;       /* leading between lines */
  char                   unused;        /* not used */
  Point                  numer;         /* current drawing scale */
  Point                  denom;         /* current drawing scale */
} FMOutput, *FMOutPtr;

typedef struct FontRec {
  short                  fontType;      /* font type */
  short                  firstChar;     /* ASCII code of first character */
  short                  lastChar;      /* ASCII code of last character */
  short                  widMax;        /* maximum character width */
  short                  kernMax;       /* negative of maximum character kern */
  short                  nDescent;      /* negative of descent */
  short                  fRectWidth;    /* width of font rectangle */
  short                  fRectHeight;   /* height of font rectangle */
  short                  owTLoc;        /* offset to offset/width table */
  short                  ascent;        /* ascent */
  short                  descent;       /* descent */
  short                  leading;       /* leading */
  short                  rowWords;      /* row width of bit image / 2 */ /*
  short                  bitImage[(rowWords-1)+1][(fRectHeight-1)+1];
  short                  locTable[(lastChar+2-firstChar)+1];
  short                  owTable[(lastChar+2-firstChar)+1];
  short                  widthTab[(lastChar+2-firstChar)+1];
  short                  heightTab[(lastChar+2-firstChar)+1]; */
} FontRec;

typedef struct FMetricRec {
  Fixed                  ascent;
  Fixed                  descent;
  Fixed                  leading;
  Fixed                  widMax;
  Handle                 wTabHandle;
} FMetricRec;
```

```
typedef struct WidthTable {
  Fixed               tabData[256];   /* character widths */
  Handle              tabFont;        /* font record used to build table */
  long                sExtra;         /* space extra used for table */
  long                style;          /* extra because of style */
  short               fID;            /* font family ID */
  short               fSize;          /* font size request */
  short               face;           /* style (face) request */
  short               device;         /* device requested */
  Point               inNumer;        /* vertical input scale factor */
  Point               inDenom;        /* horizontal input scale factor */
  short               aFID;           /* actual font family ID for table */
  Handle              fHand;          /* family record used to build table */
  Boolean             usedFam;        /* used fixed-point family widths? */
  unsigned char       aFace;          /* actual face produced */
  short               vOutput;        /* vert output scale factor--true */
  short               hOutput;        /* horiz output scale factor--true */
  short               vFactor;        /* vert output scale factor--pretty */
  short               hFactor;        /* horiz output scale factor--pretty */
  short               aSize;          /* actual size of actual font used */
  short               tabSize;        /* total size of table */
} WidthTable;

typedef struct FamRec {
  short               ffFlags;        /* flags for family */
  short               ffFamID;        /* family ID number */
  short               ffFirstChar;    /* ASCII code of first char */
  short               ffLastChar;     /* code of last char */
  short               ffAscent;       /* max ascent for 1-pt. font */
  short               ffDescent;      /* max descent for 1-pt. font */
  short               ffLeading;      /* max leading for 1-pt. font */
  short               ffWidMax;       /* max width for 1-pt. font */
  long                ffWTabOff;      /* offset to width table */
  long                ffKernOff;      /* offset to kerning table */
  long                ffStylOff;      /* offset to style-mapping table */
  short               ffProperty[9];  /* style property info */
  short               ffIntl[2];      /* for international use */
  short               ffVersion;      /* version number */ /*
  FontAssoc           ffAssoc;
  WidTable            ffWidthTab;
  StyleTable          ffSyTab;
  KernTable           ffKernTab;
*/
} FamRec;

/* Initializing the Font Manager */

pascal void InitFonts();

/* Getting Font Information */

void GetFontName(fontNum,theName)
  short fontNum;
```

```
   char *theName;
void GetFNum(fontName,theNum)
   char *fontName;
   short *theNum;
pascal Boolean RealFont(fontNum,size)
   short fontNum;
   short size;

/* Keeping Fonts in Memory */

pascal void SetFontLock(lockFlag)
   Boolean lockFlag;

/* Advanced Routines */

pascal FMOutPtr FMSwapFont(inRec)
   FMInput *inRec;
pascal void FontMetrics(theMetrics)
   FMetricRec *theMetrics;
pascal void SetFScaleDisable(fscaleDisable)
   Boolean fscaleDisable;
void SetFractEnable(fractEnable)
   Boolean fractEnable;
```

Description

The Font Manager supports the character fonts used to draw text with QuickDraw. For more detailed information, see the Font Manager chapter of *Inside Macintosh*.

Graf3D—three-dimensional graphics routines

Synopsis

```
#include  <Types.h>

#include  <QuickDraw.h>

#include  <Graf3D.h>

#define   radConst       3754936 /* radConst = 57.29578 */

typedef struct Point3D {
   Fixed                 x,y,z;
} Point3D;

typedef struct Point2D {
   Fixed                 x,y;
} Point2D;

typedef Fixed XfMatrix[4][4];

typedef struct Port3D {
   GrafPtr               grPort;
   Rect                  viewRect;
   Fixed                 xLeft,yTop,xRight,yBottom;
   Point3D               pen,penPrime,eye;
   Fixed                 hSize,vSize;
   Fixed                 hCenter,vCenter;
   Fixed                 xCotan,yCotan;
   char                  ident;
   char                  filler;
   XfMatrix              xForm;
} Port3D,*Port3DPtr;

pascal void InitGrf3D(port)
   Port3DPtr *port;
pascal void Open3DPort(port)
   Port3DPtr port;
pascal void SetPort3D(port)
   Port3DPtr port;
pascal void GetPort3D(port)
   Port3D *port;
pascal void MoveTo2D(x,y)
   Fixed x,y;
pascal void MoveTo3D(x,y,z)
   Fixed x,y,z;
pascal void LineTo2D(x,y)
   Fixed x,y;
pascal void LineTo3D(x,y,z)
   Fixed x,y,z;
pascal void Move2D(x,y)
   Fixed x,y;
pascal void Move3D(x,y,z)
   Fixed x,y,z;
```

```
pascal void Line2D(x,y)
  Fixed x,y;
pascal void Line3D(x,y,z)
  Fixed x,y,z;
pascal void ViewPort(r)
  Rect *r;
pascal void LookAt(left,top,right,bottom)
  Fixed left,top,right,bottom;
pascal void ViewAngle(angle)
  Fixed angle;
pascal void Identity();
pascal void Scale(xFactor,yFactor,zFactor)
  Fixed xFactor,yFactor,zFactor;
pascal void Translate(dx,dy,dz)
  Fixed dx,dy,dz;
pascal void Pitch(xAngle)
  Fixed xAngle;
pascal void Yaw(yAngle)
  Fixed yAngle;
pascal void Roll(zAngle)
  Fixed zAngle;
pascal void Skew(zAngle)
  Fixed zAngle;
pascal void Transform(src,dst)
  Point3D *src,*dst;
pascal short Clip3D(src1,src2,dst1,dst2)
  Point3D *src1,*src2;
  Point *dst1,*dst2;
pascal void SetPt3D(pt3D,x,y,z)
  Point3D *pt3D;
  Fixed x,y,z;
pascal void SetPt2D(pt2D,x,y)
  Point2D *pt2D;
  Fixed x,y;
```

Description

The Graf3D routines are an extension of QuickDraw that provide three-dimensional graphics.

For more detailed information, see Appendix D, "Graf3D: Three-Dimensional Graphics."

Lists—List Manager Package

Synopsis

```
#include <Types.h>
#include <Lists.h>

/* Masks for Automatic Scrolling */

#define   lDoVAutoscroll        2
#define   lDoHAutoscroll        1

/* Masks for Selection Flags */

#define   lOnlyOne          (-128)
#define   lExtendDrag         0x40
#define   lNoDisjoint         0x20
#define   lNoExtend           0x10
#define   lNoRect             0x08
#define   lUseSense           0x04
#define   lNoNilHilite        0x02

/* Messages to List Definition Procedure */

#define   lInitMsg              0
#define   lDrawMsg              1
#define   lHiliteMsg            2
#define   lCloseMsg             3

/* Data Types */

typedef Point Cell;

typedef struct ListRec  {
   Rect                      rView;
   GrafPtr                   port;
   Point                     indent;
   Point                     cellSize;
   Rect                      visible;
   struct ControlRecord      **vScroll;
   struct ControlRecord      **hScroll;
   char                      selFlags;
   char                      lActive;
   char                      lReserved;
   char                      listFlags;
   long                      clikTime;
   Point                     clikLoc;
   Point                     mouseLoc;
   ProcPtr                   lClikLoop;
   Cell                      lastClick;
   long                      refCon;
```

```
    Handle                  listDefProc;
    Handle                  userHandle;
    Rect                    dataBounds;
    Handle                  cells;
    short                   maxIndex;
    short                   cellArray[1];
} ListRec,*ListPtr,**ListHandle;

/* Creating and Disposing of Lists */

ListHandle LNew(rView,dataBounds,cSize,theProc,theWindow,
drawIt,hasGrow,scrollHoriz,scrollVert)
    Rect *rView,*dataBounds;
    Point *cSize;
    short theProc;
    struct GrafPort *theWindow;
    Boolean drawIt,hasGrow,scrollHoriz,scrollVert;
pascal void LDispose(lHandle)
    ListHandle lHandle;

/* Adding and Deleting Rows and Columns */

pascal short LAddColumn(count,colNum,lHandle)
    short count,colNum;
    ListHandle lHandle;
pascal short LAddRow(count,rowNum,lHandle)
    short count,rowNum;
    ListHandle lHandle;
pascal void LDelColumn(count,colNum,lHandle)
    short count,colNum;
    ListHandle lHandle;
pascal void LDelRow(count,rowNum,lHandle)
    short count,rowNum;
    ListHandle lHandle;

/* Operations on Cells */

void LAddToCell(dataPtr,dataLen,theCell,lHandle)
    Ptr dataPtr;
    short dataLen;
    Cell *theCell;
    ListHandle lHandle;
void LClrCell(theCell,lHandle)
    Cell *theCell;
    ListHandle lHandle;
void LGetCell(dataPtr,dataLen,theCell,lHandle)
    Ptr dataPtr;
    short *dataLen;
    Cell *theCell;
    ListHandle lHandle;
void LSetCell(dataPtr,dataLen,theCell,lHandle)
    Ptr dataPtr;
    short dataLen;
```

```
  Cell *theCell;
  ListHandle lHandle;
void LCellSize(cSize,lHandle)
  Point *cSize;
  ListHandle lHandle;
pascal Boolean LGetSelect (next,theCell,lHandle)
  Boolean next;
  Cell *theCell;
  ListHandle lHandle;
void LSetSelect(setIt,theCell,lHandle)
  Boolean setIt;
  Cell *theCell;
  ListHandle lHandle;

/* Mouse Location */

Boolean LClick(pt,modifiers,lHandle)
  Point *pt;
  short modifiers;
  ListHandle lHandle;
pascal Cell LLastClick(lHandle)
  ListHandle lHandle;

/* Accessing Cells */

void LFind(offset,len,theCell,lHandle)
  short *offset,*len;
  Cell *theCell;
  ListHandle lHandle;
pascal Boolean LNextCell(hNext,vNext,theCell,lHandle)
  Boolean hNext,vNext;
  Cell *theCell;
  ListHandle lHandle;
void LRect(cellRect,theCell,lHandle)
  Rect *cellRect;
  Cell *theCell;
  ListHandle lHandle;
pascal Boolean LSearch(dataPtr,dataLen,searchProc,theCell,lHandle)
  Ptr dataPtr;
  short dataLen;
  ProcPtr searchProc;
  Cell *theCell;
  ListHandle lHandle;
pascal void LSize(listWidth,listHeight,lHandle)
  short listWidth,listHeight;
  ListHandle lHandle;

/* List Display */

void LDraw(theCell,lHandle)
  Cell *theCell;
  ListHandle lHandle;
pascal void LDoDraw(drawIt,lHandle)
```

```
  Boolean drawIt;
  ListHandle lHandle;
pascal void LScroll(dCols,dRows,lHandle)
  short dCols,dRows;
  ListHandle lHandle;
pascal void LAutoScroll(lHandle)
  ListHandle lHandle;
pascal void LUpdate(theRgn,lHandle)
  RgnHandle theRgn;
  ListHandle lHandle;
pascal void LActivate(act,lHandle)
  Boolean act;
  ListHandle lHandle;
```

User routines

```
pascal void

MyListDef(lMessage,lSelect,lRect,lCell,lDataOffset,
     lDataLen,lHandle)
  short lMessage;
  Boolean lSelect;
  Rect *lRect;
  Cell lCell;
  short lDataOffset,lDataLen;
  ListHandle lHandle;
```

Description

The List Manager Package lets you create, display, and manipulate lists.

For more detailed information, see the List Manager Package chapter of *Inside Macintosh,* Volume 4.

Memory—Memory Manager

Synopsis

```
#include  <Types.h>
#include  <Memory.h>

typedef long Size;

typedef struct Zone {
  Ptr       bkLim;          /* limit pointer */
  Ptr       purgePtr;       /* used internally */
  Ptr       hFstFree;       /* first free master pointer */
  long      zcbFree;        /* number of free bytes */
  ProcPtr   gzProc;         /* grow zone function */
  short     moreMast;       /* master pointers to allocate */
  short     flags;          /* used internally */
  short     cntRel;         /* relocatable blocks */
  short     maxRel;         /* maximum cntRel value */
  short     cntNRel;        /* nonrelocatable blocks */
  short     maxNRel;        /* maximum maxRel value */
  short     cntEmpty;       /* empty master pointers */
  short     cntHandles;     /* total master pointers */
  long      minCBFree;      /* minimum zcbFree value */
  ProcPtr   purgeProc;      /* purge warning procedure */
  Ptr       sparePtr;       /* used internally */
  Ptr       allocPtr;       /* used internally */
  short     heapData;       /* first usable byte in zone */
} Zone, *THz;

/* Initialization and Allocation */

void InitApplZone();
void SetApplBase(startPtr)
  Ptr startPtr;
void InitZone(pGrowZone,cMoreMasters,limitPtr,startPtr)
  ProcPtr pGrowZone;
  short cMoreMasters;
  Ptr limitPtr,startPtr;
Ptr GetApplLimit();
void SetApplLimit(zoneLimit)
  Ptr zoneLimit;
void MaxApplZone();
void MoreMasters();

/* Heap Zone Access */

THz GetZone();
void SetZone(hz)
  THz hz;
THz SystemZone();
THz ApplicZone();
```

```
/* Allocating and Releasing Relocatable Blocks */

Handle NewHandle(logicalSize)
   Size logicalSize;
void DisposHandle(h)
   Handle h;
Size GetHandleSize(h)
   Handle h;
void SetHandleSize(h,newSize)
   Handle h;
   Size newSize;
THz HandleZone(h)
   Handle h;
Handle RecoverHandle(p)
   Ptr p;
void ReallocHandle(h,logicalSize)
   Handle h;
   Size logicalSize;

/* Allocating and Releasing Nonrelocatable Blocks */

Ptr NewPtr(logicalSize)
   Size logicalSize;
void DisposPtr(p)
   Ptr p;
Size GetPtrSize(p)
   Ptr p;
void SetPtrSize(p,newSize)
   Ptr p;
   Size newSize;
THz PtrZone(p)
   Ptr p;

/* Freeing Space in the Heap */

long FreeMem();
Size MaxMem(grow)
   Size *grow;
Size CompactMem(cbNeeded)
   Size cbNeeded;
void ResrvMem(cbNeeded)
   Size cbNeeded;
void PurgeMem(cbNeeded)
   Size cbNeeded;
void EmptyHandle(h)
   Handle h;

/* Properties of Relocatable Blocks */

void HLock(h)
   Handle h;
void HUnlock(h)
   Handle h;
```

```
void HPurge(h)
  Handle h;
void HNoPurge(h)
  Handle h;

/* Grow Zone Operations */

void SetGrowZone(growZone)
  ProcPtr growZone;
Handle GZSaveHnd();

/* Miscellaneous Routines */

BlockMove(sourcePtr,destPtr,byteCount)
  Ptr sourcePtr, destPtr;
  Size byteCount;
Ptr TopMem();
void MoveHHi(h)
  Handle h;
OSErr MemError();
  pascal long MaxBlock();
void PurgeSpace(total,contig)
  long *total, *contig;
pascal long StackSpace();
pascal Handle NewEmptyHandle();
  void HSetRBit(h)
  Handle h;
void HClrRBit(h)
  Handle h;
int HGetState(h)
  Handle h;
void HSetState(h,flags)
  Handle h;
  short flags;
```

User routines

```
pascal long MyGrowZone(cbNeeded)
  Size cbNeeded;
```

Description

The Memory Manager provides dynamic allocation of both relocatable and nonrelocatable memory space within the system and application heaps.

For more detailed information, see the Memory Manager chapter of *Inside Macintosh*.

Menus—Menu Manager

Synopsis

```
#include  <Types.h>
#include  <Menus.h>

/* Special Characters */

#define   noMark      '\0'

/* Messages to Menu Definition Functions */

#define   mDrawMsg       0
#define   mChooseMsg     1
#define   mSizeMsg       2

/* Resource ID of Standard Menu Definition Procedure */

#define   textMenuProc 0

/* Low Memory Global: Current Text Justification */

#define   TESysJust   (*((short *)0xbac))

typedef struct MenuInfo {
   short                 menuID;
   short                 menuWidth;
   short                 menuHeight;
   ProcHandle menuProc;
   long                  enableFlags;
   Str255                menuData;
} MenuInfo,*MenuPtr,**MenuHandle;

/* Initialization and Allocation */

pascal void InitMenus();
MenuHandle NewMenu(menuID,menuTitle)
   short                 menuID;
   char                  *menuTitle;
pascal MenuHandle GetMenu(resourceID)
   short                 resourceID;
pascal void DisposeMenu(theMenu)
   MenuHandle            theMenu;
void AppendMenu(theMenu,data)
   MenuHandle            theMenu;
   char                  *data;
pascal void AddResMenu(theMenu,theType)
   MenuHandle            theMenu;
   ResType               theType;
pascal void InsertResMenu(theMenu,theType,afterItem)
```

```
  MenuHandle           theMenu;
  ResType              theType;
  short                afterItem;

/* Forming the Menu Bar */

pascal void InsertMenu(theMenu,beforeID)
  MenuHandle theMenu;
  short beforeID;
pascal void DrawMenuBar();
pascal void DeleteMenu(menuID)
  short menuID;
pascal void ClearMenuBar();
pascal Handle GetNewMBar(menuBarID)
  short menuBarID;
pascal Handle GetMenuBar();
pascal void SetMenuBar(menuList)
  Handle menuList;
pascal void DelMenuItem(theMenu,item)
  MenuHandle theMenu;
  short item;
void InsMenuItem(theMenu,itemString,afterItem)
  MenuHandle theMenu;
  char *itemString;
  short afterItem;

/* Choosing From a Menu */

long MenuSelect(startPt)
  Point *startPt;
pascal long MenuKey(ch)
  short ch;
pascal void HiliteMenu(menuID)
  short menuID;

/* Controlling Items' Appearance */

void SetItem(theMenu,item,itemString)
  MenuHandle theMenu;
  short item;
  char *itemString;
void GetItem(theMenu,item,itemString)
  MenuHandle theMenu;
  short item;
  char *itemString;
pascal void DisableItem(theMenu,item)
  MenuHandle theMenu;
  short item;
pascal void EnableItem(theMenu,item)
  MenuHandle theMenu;
  short item;
pascal void CheckItem(theMenu,item,checked)
  MenuHandle theMenu;
```

```
    short item;
    Boolean checked;
pascal void SetItemMark(theMenu,item,markChar)
    MenuHandle theMenu;
    short item;
    short markChar;
pascal void GetItemMark(menu,item,markChar)
    MenuHandle menu;
    short item;
    short *markChar;
pascal void SetItemIcon(theMenu,item,iconNum)
    MenuHandle theMenu;
    short item;
    short iconNum;
pascal void GetItemIcon(theMenu,item,iconNum)
    MenuHandle theMenu;
    short item;
    short *iconNum;
pascal void SetItemStyle(theMenu,item,chStyle)
    MenuHandle theMenu;
    short item;
    Style chStyle;
pascal void GetItemStyle(menu,item,chStyle)
    MenuHandle menu;
    short item;
    Style *chStyle;

/* Miscellaneous Utilities */

pascal void CalcMenuSize(theMenu)
    MenuHandle theMenu;
pascal short CountMItems(theMenu)
    MenuHandle theMenu;
pascal MenuHandle GetMHandle(menuID)
    short menuID;
pascal void FlashMenuBar(menuID)
    short menuID;
pascal void SetMenuFlash(count)
    short count;
```

User routines

```
pascal void MyMenu(message,theMenu,menuRect,hitPt,whichItem)
    short message;
    MenuHandle theMenu;
    Rect *menuRect;
    Point hitPt;
    short *whichItem;
```

Description

The Menu Manager provides routines for creating and using menus.

For more detailed information, see the Menu Manager chapter of *Inside Macintosh*.

Warning The names of desk accessories start with a null byte. The output parameter from `GetMenuItem` will return a string that begins with a null byte when a desk accessory is selected from the Apple menu. `OpenDeskAcc` skips over the null byte when interpreting its parameter.

OSEvents—Operating System Event Manager

Synopsis

```
#include <Types.h>
#include <OSEvents.h>

/* Event Queue Element Structure */

typedef struct EvQEl {
   struct QElem *qLink;
   short    qType;
   short    evtQWhat;
   long     evtQMessage;
   long     evtQWhen;
   Point    evtQWhere;
   short    evtQModifiers;
} EvQEl;

/* Posting and Removing Events */

OSErr PostEvent(eventCode,eventMsg)
   short eventCode;
   long eventMsg;
OSErr PPostEvent(eventCode,eventMsg,qEl)
   short eventCode;
   long eventMsg;
   EvQEl *qEl;
void FlushEvents(eventMask,stopMask)
   short eventMask;
   short stopMask;

/* Accessing Events */

Boolean GetOSEvent(eventMask,theEvent)
   short eventMask;
   struct EventRecord *theEvent;
Boolean OSEventAvail(eventMask,theEvent)
   short eventMask;
   struct EventRecord *theEvent;

/* Setting the System Event Mask */

void SetEventMask(theMask)
   short theMask;

/* Directly Accessing the Event Queue */

struct QHdr *GetEvQHdr();
```

Description The Operating System Event Manager provides a low-level interface to the Macintosh keyboard, keypad, and mouse.

For more detailed information, see the Operating System Event Manager chapter of *Inside Macintosh*.

OSUtils—Operating System Utilities

Synopsis

```
#include  <Types.h>
#include  <OSUtils.h>

/* Serial Port Configuration Constants for Config Field of SysParmType */

#define  useFree   0  /* use undefined */
#define  useATalk  1  /* AppleTalk */
#define  useAsync  2  /* Async */

/* Values Returned by Environs Procedure */

#define  macXLMachine  0  /* Macintosh XL */
#define  macMachine    1  /* Macintosh */

/* Data Types */


/* typedef long OSType; appears in file Types.h */

/* typedef short OSErr; appears in file Types.h */

typedef struct SysParmType {
   char   valid;       /* validity status */
   char   aTalkA;      /* AppleTalk node # hint for port A */
   char   aTalkB;      /* AppleTalk node # hint for port B */
   char   config;      /* AppleTalk serial port configuration */
                       /* port A = bits 4-7, B = bits 0-3 */
   short  portA;       /* modem port configuration */
   short  portB;       /* printer port configuration */
   long   alarm;       /* alarm setting */
   short  font;        /* default application font number--1 */
   short  kbdPrint;    /* auto-key threshold and rate, */
                       /* printer connection */
   short  volClik;     /* speaker volume, double-click, and */
                       /* caret-blink times */
   short  misc;        /* mouse scaling, system startup disk, */
                       /* and menu blink */
} SysParmType, *SysPPtr;

typedef struct QElem {
   struct QElem *qLink;  /* next queue entry */
   short  qType;         /* queue type */
   short  qData[1];      /* queue type specific data */
} QElem, *QElemPtr;

typedef struct QHdr {
   short      qFlags;  /* queue flags */
```

```
  QElemPtr   qHead;  /* first queue entry */
  QElemPtr   qTail;  /* last queue entry */
} QHdr, *QHdrPtr;

typedef enum {
  dummyType,
  vType,     /* vertical retrace queue type */
  ioQType,   /* file I/O or driver I/O type */
  drvQType,  /* drive queue type */
  evType,    /* event queue type */
  fsQType    /* volume-control-block queue type */
} QTypes;

typedef struct DateTimeRec {
  short  year;       /* four-digit year */
  short  month;      /* 1 to 12 for January to December */
  short  day;        /* 1 to 31 */
  short  hour;       /* 0 to 23 */
  short  minute;     /* 0 to 59 */
  short  second;     /* 0 to 59 */
  short  dayOfWeek;  /* 1 to 7 for Sunday to Saturday */
} DateTimeRec;

typedef enum {
  OSTrap,
  ToolTrap
} TrapType;

/* Pointer and Handle Manipulation */

OSErr HandToHand(theHndl)
  Handle *theHndl;
OSErr PtrToHand(srcPtr,dstHndl,size)
  Ptr srcPtr;
  Handle *dstHndl;
  long size;
OSErr PtrToXHand(srcPtr,dstHndl,size)
  Ptr srcPtr;
  Handle dstHndl;
  long size;
OSErr HandAndHand(aHndl,bHndl)
  Handle aHndl,bHndl;
OSErr PtrAndHand(pntr,hndl,size)
  Ptr pntr;
  Handle hndl;
  long size;

/* String Comparison */

Boolean EqualString(aStr,bStr,caseSens,diacSens)
  char *aStr,*bStr;
  Boolean caseSens,diacSens;
void UprString(theString,diacSens)
```

```
  char *theString;
  Boolean diacSens;
short RelString(aStr,bStr,caseSens,diacSens)
  char *aStr,*bStr;
  Boolean caseSens,diacSens;

/* Date and Time Operations */

OSErr ReadDateTime(secs)
  long *secs;
void GetDateTime(secs)
  long *secs;
OSErr SetDateTime(secs)
  long secs;
void Date2Secs(date,secs)
  DateTimeRec *date;
  long *secs;
void Secs2Date(secs,date)
  long secs;
  DateTimeRec *date;
void GetTime(date)
  DateTimeRec *date;
void SetTime(date)
  DateTimeRec *date;

/* Parameter RAM Operations */

OSErr InitUtil();
SysPPtr GetSysPPtr();
OSErr WriteParam();

/* Queue Manipulation */

void Enqueue(qEntry,theQueue)
  QElemPtr qEntry;
  QHdrPtr theQueue;
OSErr Dequeue(qEntry,theQueue)
  QElemPtr qEntry;
  QHdrPtr theQueue;

/* Dispatch Table Utilities */

void SetTrapAddress(trapAddr,trapNum)
  long trapAddr;
  short trapNum;
long GetTrapAddress(trapNum)
  short trapNum;
long NGetTrapAddress(trapNum,tType)
  short trapNum;
  TrapType tType;
void NSetTrapAddress(trapAddr,trapNum,tType)
  long trapAddr;
  short trapNum;
```

```
    TrapType tType;

/* Miscellaneous Utilities */

void Delay(numTicks,finalTicks)
    long numTicks;
    long *finalTicks;
pascal void SysBeep(duration)
    short duration;
void Environs(rom,machine)
    short *rom,*machine;
void Restart();
```

Description

The Operating System Utilities are a set of routines and data types in the operating system that perform generally useful operations such as manipulating pointers and handles, comparing strings, and reading the date and time.

For more detailed information, see the Operating System Utilities chapter of *Inside Macintosh*.

Packages—Package Manager, Disk Initialization, Standard File Package, International Utilities, Binary-Decimal Conversion

Synopsis

```
#include <Types.h>
#include <Packages.h>

/* Package Manager ------------------------------------------ */
/* Resource IDs for Packages */

#define  listMgr   0  /* List Manager */
#define  dskInit   2  /* Disk Initializaton */
#define  stdFile   3  /* Standard File */
#define  flPoint   4  /* Floating-Point Arithmetic */
#define  trFunct   5  /* Transcendental Functions */
#define  intUtil   6  /* International Utilities */
#define  bdConv    7  /* Binary-Decimal Conversion */

pascal void InitAllPacks();

pascal void InitPack(packID)
  short packID;

/* Standard File Package ------------------------------------ */

/* SFPutFile Dialog Template ID */
#define      putDlgID        (-3999)   /* SFPutFile dialog template ID */

/* Item Numbers of Enabled Items in SFPutFile Dialog */

#define  putSave     1  /* Save button */
#define  putCancel   2  /* Cancel button */
#define  putEject    5  /* Eject button */
#define  putDrive    6  /* Drive button */
#define  putName     7  /* editText item for file name */

/* SFGetFile Dialog Template ID */

#define      getDlgID        (-4000)   /* SFGetFile dialog template ID */

/* Item Numbers of Enabled Items in SFGetFile Dialog */

#define  getOpen     1  /* Open button */
#define  getCancel   3  /* Cancel button */
#define  getEject    5  /* Eject button */
#define  getDrive    6  /* Drive button */
#define  getNmList   7  /* userItem for filename list */
```

```
#define   getScroll   8  /* userItem for scroll bar */

/* Data Types */

typedef struct SFReply {
  Boolean              good;          /* false if ignore command */
  Boolean              copy;          /* not used */
  OSType               fType;         /* file type or not used */
  short                vRefNum;       /* volume reference number */
  short                version;       /* file's version number */
  String(63)           fName;         /* filename */
} SFReply;

typedef OSType SFTypeList[4];

/* Standard File Operations */

void SFPutFile(where,prompt,origName,dlgHook,reply)
  Point *where;
  char *prompt;
  char *origName;
  ProcPtr dlgHook;
  SFReply *reply;
void SFPPutFile(where,prompt,origName,dlgHook,reply,dlgID,filterProc)
  Point *where;
  char *prompt;
  char *origName;
  ProcPtr dlgHook;
  SFReply *reply;
  short dlgID;
  ProcPtr filterProc;
void SFGetFile(where,prompt,fileFilter,numTypes,typeList,dlgHook,reply)
  Point *where;
  char *prompt;
  ProcPtr fileFilter;
  short numTypes;
  SFTypeList typeList;
  ProcPtr dlgHook;
  SFReply *reply;
void SFPGetFile(where,prompt,fileFilter,numTypes,typeList,dlgHook,reply,
    dlgID,filterProc)
  Point *where;
  char *prompt;
  ProcPtr fileFilter;
  short numTypes;
  SFTypeList typeList;
  ProcPtr dlgHook;
  SFReply *reply;
  short dlgID;
  ProcPtr filterProc;
```

```
/* International Utilities Package ----------------------------- */

/* Masks for Currency Format */

#define      currSymLead    16     /* set if currency symbol leads */
#define      currNegSym       32      /* set if minus sign for negative */
#define      currTrailingZ    64      /* set if trailing decimal zeros */
#define      currLeadingZ     128     /* set if leading integer zeros */

/* Order of Short Date Elements */

#define      mdy              0       /* month day year */
#define      dmy              1       /* day month year */
#define      ymd              2       /* year month day */

/* Masks for Short Date Format */

#define      dayLdingZ        32      /* set if leading zero for day */
#define      mntLdingZ        64      /* set if leading zero for month */
#define      century          128     /* set if century included */

/* Masks for Time Format */

#define      secLeadingZ      32      /* set if leading zero for seconds */
#define      minLeadingZ      64      /* set if leading zero for minutes */
#define      hrLeadingZ       128     /* set if leading zero for hours */

/* High-Order Byte of Version Information */

#define      verUS            0
#define      verFrance        1
#define      verBritain       2
#define      verGermany       3
#define      verItaly         4
#define      verNetherlands   5
#define      verBelgiumLux    6
#define      verSweden        7
#define      verSpain         8
#define      verDenmark       9
#define      verPortugal      10
#define      verFrCanada      11
#define      verNorway        12
#define      verIsrael        13
#define      verJapan         14
#define      verAustralia     15
#define      verArabia        16
#define      verFinland       17
#define      verFrSwiss       18
#define      verGrSwiss       19
#define      verGreece        20
#define      verIceland       21
#define      verMalta         22
```

```
#define      verCyprus        23
#define      verTurkey        24
#define      verYugoslavia    25

/* Data Types */

typedef struct Intl0Rec {
  char                  decimalPt;      /* decimal point character */
  char                  thousSep;       /* thousands separator */
  char                  listSep;        /* list separator */
  char                  currSym1;       /* currency symbols (3 bytes long) */
  char                  currSym2;
  char                  currSym3;
  unsigned char         currFmt;        /* currency format */
  unsigned char         dateOrder;      /* short date order--dmy, ymd, or mdy */
  unsigned char         shrtDateFmt;    /* short date format */
  char                  dateSep;        /* date separator */
  unsigned char         timeCycle;      /* 0 if 24-hour cycle, 255 if 1-hour */
  unsigned char         timeFmt;        /* time format */
  char                  mornStr[4];     /* trailing string for first 12 hours */
  char                  eveStr[4];      /* trailing string for last 12 hours */
  char                  timeSep;        /* time separator */
  char                  time1Suff;      /* trailing string for 24-hour cycle */
  char                  time2Suff;
  char                  time3Suff;
  char                  time4Suff;
  char                  time5Suff;
  char                  time6Suff;
  char                  time7Suff;
  char                  time8Suff;
  unsigned char         metricSys;      /* 255 for metric, 0 if not */
  short                 intl0Vers;      /* version information--country, vers */
} Intl0Rec, *Intl0Ptr, **Intl0Hndl;

typedef struct Intl1Rec {
  String(15)            days[7];        /* day names */
  String(15)            months[12];     /* month names */
  unsigned char         suppressDay;    /* 0 for day name, 255 for none */
  unsigned char         lngDateFmt;     /* order of long date elements */
  unsigned char         dayLeading0;    /* 255 for leading 0 in day number */
  unsigned char         abbrLen;        /* length for abbreviating names */
  char                  st0[4];         /* date punctuation  */
  char                  st1[4];
  char                  st2[4];
  char                  st3[4];
  char                  st4[4];
  short                 intl1Vers;      /* version information */
  short                 localRtn[1];    /* routine for string comparison */
} Intl1Rec, *Intl1Ptr, **Intl1Hndl;

typedef enum {
  shortDate,
  longDate,
  abbrevDate
} DateForm;

/* Routines */

void IUDateString(dateTime,form,result)
  long dateTime;
  DateForm form;
  char *result;
void IUDatePString(dateTime,form,result,intlParam)
  long dateTime;
  DateForm form;
  char *result;
  Handle intlParam;
void IUTimeString(dateTime,wantSeconds,result)
  long dateTime;
  Boolean wantSeconds;
  char *result;
void IUTimePString(dateTime,wantSeconds,result,intlParam)
  long dateTime;
  Boolean wantSeconds;
  char *result;
  Handle intlParam;
Boolean IUMetric();
Handle IUGetIntl(theID)
  short theID;
void IUSetIntl(refNum,theID,intlParam)
  short refNum;
  short theID;
  Handle intlParam;
short IUCompString(aStr,bStr)
  char *aStr,*bStr;
short IUMagString(aPtr,bPtr,aLen,bLen)
  Ptr aPtr,bPtr;
  short aLen,bLen;
short IUEqualString(aStr,bStr)
  char *aStr,*bStr;
short IUMagIDString(aPtr,bPtr,aLen,bLen)
  Ptr aPtr,bPtr;
  short aLen,bLen;

/* Binary-Decimal Conversion Package -------------------------- */

void NumToString(theNum,theString)
  long theNum;
  char *theString;
void StringToNum(theString,theNum)
  char *theString;
  long *theNum;
```

User routines

```
/* Standard File Package ------------------------------------ */
```

```
pascal short MyDlg(item,theDialog)
   short item;
   DialogPtr theDialog;
pascal Boolean MyFileFilter(paramBlock)
   ParmBlkPtr paramBlock;
```

Description

The Package Manager provides for the initialization of packages.

For more detailed information, see the chapters for Package Manager, Disk Initialization Package, Standard File Package, International Utilities Package, and Binary-Decimal Conversion Package in *Inside Macintosh*.

Printing—Printing Manager

Synopsis

```
#include  <Types.h>
#include  <QuickDraw.h>
#include  <Printing.h>

/* Printing Methods */

#define   bDraftLoop                0  /* draft printing */
#define   bSpoolLoop                1  /* spooling */

/* Printer Specification in prStl Field of Print Record */

#define   bDevCItoh                 1  /* ImageWriter printer */
#define   bDevLaser                 3  /* LaserWriter printer */

/* Maximum Number of Pages in a Spool File */

#define   iPFMaxPgs               128  /* max pages in a spool file */
#define   iPrPgFract              120  /* paper units per inch */

/* Result Codes */

#define   iPrSavPFil              (-1)  /* saving spool file */
#define   iIOAbort               (-27)  /* I/O abort error */
#define   iPrAbort                128  /* application- or user-requested abort */

/* PrCtlCall Parameters */

#define   iPrDevCtl                 7  /* device control */
#define   lPrReset         0x00010000  /* reset printer */
#define   lPrLineFeed      0x00030000  /* start new line */
#define   lPrLFSixth       0x0003FFFF  /* standard 1/6" line feed */
#define   lPrPageEnd       0x00020000  /* start new page */
#define   iPrBitsCtl                4  /* bit-map printing */
#define   lScreenBits               0  /* configurable */
#define   lPaintBits                1  /* 72 x 72 dots */
#define   iPrIOCtl                  5  /* text streaming */

/* Printer Driver Information */

#define   sPrDrvr            ".Print"  /* Printer Driver resource name */
#define   iPrDrvrRef             (-3)  /* Printer Driver reference number */
#define   bDevCItoh                 1
#define   iDevCItoh  (bDevCItoh << 8)
#define   bDevDaisy                 2
#define   iDevDaisy  (bDevDaisy << 8)
#define   bDevLaser                 3
```

```
#define   iDevLaser  (bDevLaser << 8)

/* Type Definitions */

typedef Rect *TPRect;

typedef struct TPrPort {
    GrafPort            gPort;          /* graph port to draw in */
    QDProcs             gProcs;         /* pointers to drawing routines */
    long                lGParam1;       /* internal */
    long                lGParam2;       /* internal */
    long                lGParam3;       /* internal */
    long                lGParam4;       /* internal */
    Boolean             fOurPtr;        /* internal */
    Boolean             fOurBits;       /* internal */
} TPrPort, *TPPrPort;

typedef struct TPrInfo {
    short               iDev;           /* printer information */
    short               iVRes;          /* printer vertical resolution */
    short               iHRes;          /* printer horizontal resolution */
    Rect                rPage;          /* page rectangle */
} TPrInfo;

typedef enum {
    feedCut,
    feedFanfold,
    feedMechCut,
    feedOther
} TFeed;

typedef struct TPrStl {
    short               wDev;           /* high byte specifies device */
    short               iPageV;         /* paper height */
    short               iPageH;         /* paper width */
    char                bPort;          /* printer or modem port--ignored */
    TFeed               feed;           /* paper type */
} TPrStl;

typedef enum {
    scanTB,
    scanBT,
    scanLR,
    scanRL
} TScan;

typedef struct TPrXInfo {
    short               iRowBytes;      /* bytes per row */
    short               iBandV;         /* vertical dots */
    short               iBandH;         /* horizontal dots */
    short               iDevBytes;      /* size of bit image */
    short               iBands;         /* bands per page */
    char                bPatScale;      /* used by QuickDraw */
```

```
   char                  bUlThick;        /* underline thickness */
   char                  bUlOffset;       /* underline offset */
   char                  bUlShadow;       /* underline descender */
   TScan                 scan;            /* scan direction */
   char                  bXInfoX;         /* not used */
} TPrXInfo;

typedef struct TPrJob {
   short                 iFstPage;        /* first page to print */
   short                 iLstPage;        /* last page to print */
   short                 iCopies;         /* number of copies */
   char                  bJDocLoop;       /* printing method */
   Boolean               fFromUsr;        /* true if called from application */
   ProcPtr               pIdleProc;       /* background procedure */
   StringPtr             pFileName;       /* spool-file name */
   short                 iFileVol;        /* spool-file volume reference number */
   char                  bFileVers;       /* spool-file version number */
   char                  bJobX;           /* not used */
} TPrJob;

typedef struct TPrint {
   short                 iPrVersion;      /* Printing Manager version */
   TPrInfo               prInfo;          /* printing information */
   Rect                  rPaper;          /* paper rectangle */
   TPrStl                prStl;           /* style information */
   TPrInfo               prInfoPT;        /* copy of prInfo */
   TPrXInfo              prXInfo;         /* band information */
   TPrJob                prJob;           /* job information */
   short                 printX[19]       /* internal */
} TPrint, *TPPrint, **THPrint;

typedef struct TPrStatus {
   short                 iTotPages;       /* total number of pages */
   short                 iCurPage;        /* page being printed */
   short                 iTotCopies;      /* number of copies */
   short                 iCurCopy;        /* copy begin printed */
   short                 iTotBands;       /* bands per page */
   short                 iCurBand;        /* band being printed */
   Boolean               fPgDirty;        /* true if started printing page */
   Boolean               fImaging;        /* true if imaging */
   THPrint               hPrint;          /* print record */
   TPPrPort              pPrPort;         /* printing port */
   PicHandle             hPic;            /* internal */
} TPrStatus;

/* Initialization and Termination */

pascal void PrOpen();

pascal void PrClose();
```

```
/* Print Records and Dialogs */

pascal void PrintDefault(hPrint)
  THPrint hPrint;
pascal Boolean PrValidate(hPrint)
  THPrint hPrint;
pascal Boolean PrStlDialog(hPrint)
  THPrint hPrint;
pascal Boolean PrJobDialog(hPrint)
  THPrint hPrint;
pascal void PrJobMerge(hPrintSrc,hPrintDst)
  THPrint hPrintSrc,hPrintDst;

/* Printing */

pascal TPPrPort PrOpenDoc(hPrint,pPrPort,pIOBuf)
  THPrint hPrint;
  TPPrPort pPrPort;
  Ptr pIOBuf;
pascal void PrOpenPage(pPrPort,pPageFrame)
  TPPrPort pPrPort;
  TPRect pPageFrame;
pascal void PrClosePage(pPrPort)
  TPPrPort pPrPort;
pascal void PrCloseDoc(pPrPort)
  TPPrPort pPrPort;

/* Spool Printing */

pascal void PrPicFile(hPrint,pPrPort,pIOBuf,pDevBuf,prStatus)
  THPrint hPrint;
  TPPrPort pPrPort;
  Ptr pIOBuf;
  Ptr pDevBuf;
  TPrStatus *prStatus;

/* Error Handling */

pascal short PrError();
pascal void PrSetError(iErr)
  short iErr;

/* Low-Level Driver Access */

pascal void PrDrvrOpen();
pascal void PrDrvrClose();
pascal void PrCtlCall(iWhichCtl,lParam1,lParam2,lParam3)
  short iWhichCtl;
  long lParam1,lParam2,lParam3;
pascal Handle PrDrvrDCE();
pascal short PrDrvrVers();
```

Description The Printing Manager supports printing on a variety of devices.

For more detailed information, see the Printing Manager chapter of *Inside Macintosh*.

QuickDraw—graphics routines

Synopsis

```
/* Source Transfer Modes */

#define  srcCopy        0
#define  srcOr          1
#define  srcXor         2
#define  srcBic         3
#define  notSrcCopy     4
#define  notSrcOr       5
#define  notSrcXor      6
#define  notSrcBic      7

/* Pattern Transfer Modes */

#define  patCopy        8
#define  patOr          9
#define  patXor        10
#define  patBic        11
#define  notPatCopy    12
#define  notPatOr      13
#define  notPatXor     14
#define  notPatBic     15

/* QuickDraw Color-Separation Constants */

#define  normalBit      0
#define  inverseBit     1
#define  redBit         4  /* RGB additive mapping */
#define  greenBit       3
#define  blueBit        2
#define  cyanBit        8  /* CMYBk subtractive mapping */
#define  magentaBit     7
#define  yellowBit      6
#define  blackBit       5

/* Standard Colors for ForeColor and BackColor */

#define  blackColor     33  /* colors expressed in these mappings */
#define  whiteColor     30
#define  redColor      205
#define  greenColor    341
#define  blueColor     409
#define  cyanColor     273
#define  magentaColor  137
#define  yellowColor    69

/* Standard Picture Comments */

#define  picLParen      0
#define  picRParen      1
```

```
/* Type-Style Constants */

#define  normal        0x00
#define  bold          0x01
#define  italic        0x02
#define  underline     0x04
#define  outline       0x08
#define  shadow        0x10
#define  condense      0x20
#define  extend        0x40

/* Data Types */

typedef unsigned char Pattern[8];
typedef short Bits16[16];
typedef enum {frame,paint,erase,invert,fill} GrafVerb;

/* The typedefs Style, Point, and Rect appear in file Types.h.*/

typedef struct FontInfo {
  short                  ascent;
  short                  descent;
  short                  widMax;
  short                  leading;
} FontInfo;

typedef struct BitMap {
  Ptr                    baseAddr;
  short                  rowBytes;
  Rect                   bounds;
} BitMap;

typedef struct Cursor {
  Bits16                 data;
  Bits16                 mask;
  Point                  hotSpot;
} Cursor;

typedef struct PenState {
  Point                  pnLoc;
  Point                  pnSize;
  short                  pnMode;
  Pattern                pnPat;
} PenState;

typedef struct Region {
  short                  rgnSize;
  Rect                   rgnBBox;
  short                  rgnData[1];
} Region, *RgnPtr, **RgnHandle;

typedef struct Picture {
    short                    picSize;
    Rect                     picFrame;
    short                    picData[1];
} Picture, *PicPtr, **PicHandle;

typedef struct Polygon {
    short                    polySize;
    Rect                     polyBBox;
    Point                    polyPoints[1];
} Polygon, *PolyPtr, **PolyHandle;

typedef struct QDProcs {
    ProcPtr                  textProc;
    ProcPtr                  lineProc;
    ProcPtr                  rectProc;
    ProcPtr                  rRectProc;
    ProcPtr                  ovalProc;
    ProcPtr                  arcProc;
    ProcPtr                  polyProc;
    ProcPtr                  rgnProc;
    ProcPtr                  bitsProc;
    ProcPtr                  commentProc;
    ProcPtr                  txMeasProc;
    ProcPtr                  getPicProc;
    ProcPtr                  putPicProc;
} QDProcs, *QDProcsPtr;

typedef struct GrafPort {
    short                    device;
    BitMap                   portBits;
    Rect                     portRect;
    RgnHandle                visRgn;
    RgnHandle                clipRgn;
    Pattern                  bkPat;
    Pattern                  fillPat;
    Point                    pnLoc;
    Point                    pnSize;
    short                    pnMode;
    Pattern                  pnPat;
    short                    pnVis;
    short                    txFont;
    Style                    txFace;
    short                    txMode;
    short                    txSize;
    Fixed                    spExtra;
    long                     fgColor;
    long                     bkColor;
    short                    colrBit;
    short                    patStretch;
    PicHandle                picSave;
    RgnHandle                rgnSave;
    PolyHandle               polySave;
    QDProcsPtr               grafProcs;
} GrafPort, *GrafPtr;
```

```
/* External Variable Declarations */

extern struct qd {
  char                    private[78];
  long                    randSeed;
  BitMap                  screenBits;
  Cursor                  arrow;
  Pattern                 dkGray;
  Pattern                 ltGray;
  Pattern                 gray;
  Pattern                 black;
  Pattern                 white;
  GrafPtr                 thePort;
} qd;

/* GrafPort Routines */

pascal void InitGraf(globalPtr)
  Ptr globalPtr;
pascal void OpenPort(port)
  GrafPtr port;
pascal void InitPort(port)
  GrafPtr port;
pascal void ClosePort(port)
  GrafPtr port;
pascal void SetPort(port)
  GrafPtr port;
pascal void GetPort(port)
  GrafPtr *port;
pascal void GrafDevice(device)
  short device;
pascal void SetPortBits(bm)
  BitMap *bm;
pascal void PortSize(width,height)
  short width,height;
pascal void MovePortTo(leftGlobal,rightGlobal)
  short leftGlobal,rightGlobal;
pascal void SetOrigin(h,v)
  short h,v;
pascal void SetClip(rgn)
  RgnHandle rgn;
pascal void GetClip(rgn)
  RgnHandle rgn;
pascal void ClipRect(r)
  Rect *r;
pascal void BackPat(pat)
  Pattern pat;

/* Cursor Handling */

pascal void InitCursor();
pascal void SetCursor(crsr)
  Cursor *crsr;
```

```
pascal void HideCursor();
pascal void ShowCursor();
pascal void ObscureCursor();

/* Pen and Line Drawing */

pascal void HidePen();
pascal void ShowPen();
pascal void GetPen(pt)
  Point *pt;
pascal void GetPenState(pnState)
  PenState *pnState;
pascal void SetPenState(pnState)
  PenState *pnState;
pascal void PenSize(width,height)
  short width,height;
pascal void PenMode(mode)
  short mode;
pascal void PenPat(pat)
  Pattern pat;
pascal void PenNormal();
pascal void MoveTo(h,v)
  short h,v;
pascal void Move(dh,dv)
  short dh,dv;
pascal void LineTo(h,v)
  short h,v;
pascal void Line(dh,dv)
  short dh,dv;

/* Text Drawing */

pascal void TextFont(font)
  short font;
pascal void TextFace(face)
  Style face;
pascal void TextMode(mode)
  short mode;
pascal void TextSize(size)
  short size;
pascal void SpaceExtra(extra)
  Fixed extra;
pascal void DrawChar(ch)
  short ch;
void DrawString(s)
  char *s;
pascal void DrawText(textBuf,firstByte,byteCount)
  Ptr textBuf;
  short firstByte,byteCount;
pascal short CharWidth(ch)
  short ch;
short StringWidth(s)
  char *s;
```

```
pascal short TextWidth(textBuf,firstByte,byteCount)
  Ptr textBuf;
  short firstByte,byteCount;
pascal void MeasureText(count,textAddr,charLocs)
  short count;
  Ptr textAddr,charLocs;
pascal void GetFontInfo(info)
  FontInfo *info;

/* Drawing in Color */

pascal void ForeColor(color)
  long color;
pascal void BackColor(color)
  long color;
pascal void ColorBit(whichBit)
  short whichBit;

/* Calculations With Rectangles */

pascal void SetRect(r,left,top,right,bottom)
  Rect *r;
  short left,top,right,bottom;
pascal void OffsetRect(r,dh,dv)
  Rect *r;
  short dh,dv;
pascal void InsetRect(r,dh,dv)
  Rect *r;
  short dh,dv;
pascal Boolean SectRect(src1,src2,dstRect)
  Rect *src1,*src2;
  Rect *dstRect;
pascal void UnionRect(src1,src2,dstRect)
  Rect *src1,*src2;
  Rect *dstRect;
Boolean PtInRect(pt,r)
  Point *pt;
  Rect *r;
void Pt2Rect(pt1,pt2,dstRect)
  Point *pt1, *pt2;
  Rect *dstRect;
void PtToAngle(r,pt,angle)
  Rect *r;
  Point *pt;
  short *angle;
pascal Boolean EqualRect(rect1,rect2)
  Rect *rect1,*rect2;
pascal Boolean EmptyRect(r)
  Rect *r;
```

```
/* Graphic Operations on Rectangles */

pascal void FrameRect(r)
   Rect *r;
pascal void PaintRect(r)
   Rect *r;
pascal void EraseRect(r)
   Rect *r;
pascal void InvertRect(r)
   Rect *r;
pascal void FillRect(r,pat)
   Rect *r;
   Pattern pat;

/* Graphic Operations on Ovals */

pascal void FrameOval(r)
   Rect *r;
pascal void PaintOval(r)
   Rect *r;
pascal void EraseOval(r)
   Rect *r;
pascal void InvertOval(r)
   Rect *r;
pascal void FillOval(r,pat)
   Rect *r;
   Pattern pat;

/* Graphic Operations on Rounded-Corner Rectangles */

pascal void FrameRoundRect(r,ovalWidth,ovalHeight)
   Rect *r;
   short ovalWidth,ovalHeight;
pascal void PaintRoundRect(r,ovalWidth,ovalHeight)
   Rect *r;
   short ovalWidth,ovalHeight;
pascal void EraseRoundRect(r,ovalWidth,ovalHeight)
   Rect *r;
   short ovalWidth,ovalHeight;
pascal void InvertRoundRect(r,ovalWidth,ovalHeight)
   Rect *r;
   short ovalWidth,ovalHeight;
pascal void FillRoundRect(r,ovalWidth,ovalHeight,pat)
   Rect *r;
   short ovalWidth,ovalHeight;
   Pattern pat;

/* Graphic Operations on Arcs and Wedges */

pascal void FrameArc(r,startAngle,arcAngle)
   Rect *r;
   short startAngle,arcAngle;
pascal void PaintArc(r,startAngle,arcAngle)
```

```
  Rect *r;
  short startAngle,arcAngle;
pascal void EraseArc(r,startAngle,arcAngle)
  Rect *r;
  short startAngle,arcAngle;
pascal void InvertArc(r,startAngle,arcAngle)
  Rect *r;
  short startAngle,arcAngle;
pascal void FillArc(r,startAngle,arcAngle,pat)
  Rect *r;
  short startAngle,arcAngle;
  Pattern pat;

/* Calculations With Regions */

pascal RgnHandle NewRgn();
pascal void OpenRgn();
pascal void CloseRgn(dstRgn)
  RgnHandle dstRgn;
pascal void DisposeRgn(rgn)
  RgnHandle rgn;
pascal void CopyRgn(srcRgn,dstRgn)
  RgnHandle srcRgn,dstRgn;
pascal void SetEmptyRgn(rgn)
  RgnHandle rgn;
pascal void SetRectRgn(rgn,left,top,right,bottom)
  RgnHandle rgn;
  short left,top,right,bottom;
pascal void RectRgn(rgn,r)
  RgnHandle rgn;
  Rect *r;
pascal void OffsetRgn(rgn,dh,dv)
  RgnHandle rgn;
  short dh,dv;
pascal void InsetRgn(rgn,dh,dv)
  RgnHandle rgn;
  short dh,dv;
pascal void SectRgn(srcRgnA,srcRgnB,dstRgn)
  RgnHandle srcRgnA,srcRgnB,dstRgn;
pascal void UnionRgn(srcRgnA,srcRgnB,dstRgn)
  RgnHandle srcRgnA,srcRgnB,dstRgn;
pascal void DiffRgn(srcRgnA,srcRgnB,dstRgn)
  RgnHandle srcRgnA,srcRgnB,dstRgn;
pascal void XorRgn(srcRgnA,srcRgnB,dstRgn)
  RgnHandle srcRgnA,srcRgnB,dstRgn;
Boolean PtInRgn(pt,rgn)
  Point *pt;
  RgnHandle rgn;
pascal Boolean RectInRgn(r,rgn)
  Rect *r;
  RgnHandle rgn;
pascal Boolean EqualRgn(rgnA,rgnB)
  RgnHandle rgnA,rgnB;
pascal Boolean EmptyRgn(rgn)
```

```
  RgnHandle rgn;

/* Graphic Operations on Regions */

pascal void FrameRgn(rgn)
  RgnHandle rgn;
pascal void PaintRgn(rgn)
  RgnHandle rgn;
pascal void EraseRgn(rgn)
  RgnHandle rgn;
pascal void InvertRgn(rgn)
  RgnHandle rgn;
pascal void FillRgn(rgn,pat)
  RgnHandle rgn;
  Pattern pat;

/* Bit Transfer Operations */

pascal void ScrollRect(r,dh,dv,updateRgn)
  Rect *r;
  short dh,dv;
  RgnHandle updateRgn;
pascal void CopyBits(srcBits,dstBits,srcRect,dstRect,mode,maskRgn)
  BitMap *srcBits,*dstBits;
  Rect *srcRect,*dstRect;
  short mode; RgnHandle maskRgn;
pascal void SeedFill(srcPtr,dstPtr,srcRow,dstRow,height,words,seedH,seedV)
  Ptr srcPtr,dstPtr;
  short srcRow,dstRow,height,words;
  short seedH,seedV;
pascal void CalcMask(srcPtr,dstPtr,srcRow,dstRow,height,words)
  Ptr srcPtr,dstPtr;
  short srcRow,dstRow,height,words;
pascal void CopyMask(srcBits,maskBits,dstBits,srcRect,maskRect,dstRect)
  BitMap *srcBits,*maskBits,*dstBits;
  Rect *srcRect, *maskRect, *dstRect;

/* Pictures */

pascal PicHandle OpenPicture(picFrame)
  Rect *picFrame;
pascal void PicComment(kind,dataSize,dataHandle)
  short kind,dataSize;
  Handle dataHandle;
pascal void ClosePicture();
pascal void DrawPicture(myPicture,dstRect)
  PicHandle myPicture;
  Rect *dstRect;
pascal void KillPicture(myPicture)
  PicHandle myPicture;
```

```
/* Calculations With Polygons */

pascal PolyHandle OpenPoly();
pascal void ClosePoly();
pascal void KillPoly(poly)
   PolyHandle poly;
pascal void OffsetPoly(poly,dh,dv)
   PolyHandle poly;
   short dh,dv;

/* Graphic Operations on Polygons */

pascal void FramePoly(poly)
   PolyHandle poly;
pascal void PaintPoly(poly)
   PolyHandle poly;
pascal void ErasePoly(poly)
   PolyHandle poly;
pascal void InvertPoly(poly)
   PolyHandle poly;
pascal void FillPoly(poly,pat)
   PolyHandle poly;
   Pattern pat;

/* Calculations With Points */

void AddPt(srcPt,dstPt)
   Point *srcPt,*dstPt;
void SubPt(srcPt,dstPt)
   Point *srcPt,*dstPt;
pascal void SetPt(pt,h,v)
   Point *pt;
   short h,v;
Boolean EqualPt(pt1,pt2)
   Point *pt1, *pt2;
pascal void LocalToGlobal(pt)
   Point *pt;
pascal void GlobalToLocal(pt)
   Point *pt;

/* Miscellaneous Routines */

pascal short Random();
pascal Boolean GetPixel(h,v)
   short h,v;
void StuffHex(thingPtr,s)
   Ptr thingPtr;
   char *s;
pascal void ScalePt(pt,srcRect,dstRect)
   Point *pt;
   Rect *srcRect,*dstRect;
pascal void MapPt(pt,srcRect,dstRect)
   Point *pt;
```

```
    Rect *srcRect,*dstRect;
pascal void MapRect(r,srcRect,dstRect)
    Rect *r;
    Rect *srcRect,*dstRect;
pascal void MapRgn(rgn,srcRect,dstRect)
    RgnHandle rgn;
    Rect *srcRect,*dstRect;
pascal void MapPoly(poly,srcRect,dstRect)
    PolyHandle poly;
    Rect *srcRect,*dstRect;

/* Customizing QuickDraw Operations */

pascal void SetStdProcs(procs)
    QDProcs *procs;
void StdText(byteCount,textbuf,numer,denom)
    short byteCount;
    Ptr textbuf;
    Point *numer, *denom;
void StdLine(newPt)
    Point *newPt;
pascal void StdRect(verb,r)
    GrafVerb verb;
    Rect *r;
pascal void StdRRect(verb,r,ovalWidth,ovalHeight)
    GrafVerb verb;
    Rect *r;
    short ovalWidth,ovalHeight;
pascal void StdOval(verb,r)
    GrafVerb verb;
    Rect *r;
pascal void StdArc(verb,r,startAngle,arcAngle)
    GrafVerb verb;
    Rect *r;
    short startAngle,arcAngle;
pascal void StdPoly(verb,poly)
    GrafVerb verb;
    PolyHandle poly;
pascal void StdRgn(verb,rgn)
    GrafVerb verb;
    RgnHandle rgn;
pascal void StdBits(srcBits,srcRect,dstRect,mode,maskRgn)
    BitMap *srcBits;
    Rect *srcRect,*dstRect;
    short mode;
    RgnHandle maskRgn;
pascal void StdComment(kind,dataSize,dataHandle)
    short kind,dataSize;
    Handle dataHandle;
pascal short StdTxMeas(byteCount,textAddr,numer,denom,info)
    short byteCount;
    Ptr textAddr; Point *numer,*denom;
    FontInfo *info;
pascal void StdGetPic(dataPtr,byteCount)
```

```
  Ptr dataPtr;
  short byteCount;
pascal void StdPutPic(dataPtr,byteCount)
  Ptr dataPtr;
  short byteCount;
```

User routines

```
pascal void MyText(byteCount,textbuf,numer,denom)
  short byteCount;
  Ptr textbuf;
  Point numer,denom;
pascal void MyLine(newPt)
  Point newPt;
pascal void MyRect(verb,r)
  GrafVerb verb;
  Rect *r;
pascal void MyRRect(verb,r,ovalWidth,ovalHeight)
  GrafVerb verb;
  Rect *r;
  short ovalWidth,ovalHeight;
pascal void MyOval(verb,r)
  GrafVerb verb;
  Rect *r;
pascal void MyArc(verb,r,startAngle,arcAngle)
  GrafVerb verb;
  Rect *r;
  short startAngle,arcAngle;
pascal void MyPoly(verb,poly)
  GrafVerb verb;
  PolyHandle poly;
pascal void MyRgn(verb,rgn)
  GrafVerb verb;
  RgnHandle rgn;
pascal void MyBits(srcBits,srcRect,dstRect,mode,maskRgn)
  BitMap *srcBits;
  Rect *srcRect,*dstRect;
  short mode;
  RgnHandle maskRgn;
pascal void MyComment(kind,dataSize,dataHandle)
  short kind,dataSize;
  Handle dataHandle;
pascal short MyTxMeas(byteCount,textAddr,numer,denom,info)
  short byteCount;
  Ptr textAddr;
  Point *numer,*denom;
  FontInfo *info;
pascal void MyGetPic(dataPtr,byteCount)
  Ptr dataPtr;
  short byteCount;
pascal void MyPutPic(dataPtr,byteCount)
  Ptr dataPtr;
  short byteCount;
```

Description QuickDraw is the Macintosh graphics package.

For more detailed information, see the QuickDraw chapter of *Inside Macintosh*.

Warning User routines `MyText` and `MyLine` are not identical to their counterparts `StdText` and `StdLine`. Point parameters to `MyText` and `MyLine` are passed by value; the corresponding parameters to `StdText` and `StdLine` are passed by reference.

Resources—Resource Manager

Synopsis

```
#include   <Types.h>
#include   <Resources.h>0

/* Masks for Resource Attributes */

#define    resSysHeap     64   /* set if read into system heap */
#define    resPurgeable   32   /* set if purgeable */
#define    resLocked      16   /* set if locked */
#define    resProtected    8   /* set if protected */
#define    resPreload      4   /* set if to be preloaded */
#define    resChanged      2   /* set if written to resource file */

/* Masks for Resource File Attributes */

#define    mapReadOnly   128   /* set if file is read-only */
#define    mapCompact     64   /* set to compact file on update */
#define    mapChanged     32   /* set if write map on update */

/* typedef long ResType; appears in file Types.h */

/* Initialization */

pascal short InitResources();
pascal void RsrcZoneInit();

/* Opening and Closing Resource Files */

void CreateResFile(fileName)
  char *fileName;
short OpenResFile(fileName)
  char *fileName;
pascal void CloseResFile(refNum)
  short refNum;

/* Checking for Errors */

pascal short ResError();

/* Setting the Current Resource File */

pascal short CurResFile();
pascal short HomeResFile(theResource)
  Handle theResource;
pascal void UseResFile(refNum)
  short refNum;
```

```
/* Getting Resource Types */

pascal short CountTypes();
pascal short Count1Types();
pascal void GetIndType(theType,index)
  ResType *theType;
  short index;
pascal void Get1IndType(theType,index)
  ResType *theType;
  short index;

/* Getting and Disposing of Resources */

pascal void SetResLoad(load)
  Boolean load;
pascal short CountResources(theType)
  ResType theType;
pascal short Count1Resources(theType)
  ResType theType;
pascal Handle GetIndResource(theType,index)
  ResType theType;
  short index;
pascal Handle Get1IndResource(theType,index)
  ResType theType;
  short index;
pascal Handle GetResource(theType,theID)
  ResType theType;
  short theID;
pascal Handle Get1Resource(theType,theID)
  ResType theType;
  short theID;
Handle GetNamedResource(theType,name)
  ResType theType;
  char *name;
Handle Get1NamedResource(theType,name)
  ResType theType;
  char *name;
pascal void LoadResource(theResource)
  Handle theResource;
pascal void ReleaseResource(theResource)
  Handle theResource;
pascal void DetachResource(theResource)
  Handle theResource;

/* Getting Resource Information */

pascal short UniqueID(theType)
  ResType theType;
pascal short Unique1ID(theType)
  ResType theType;
void GetResInfo(theResource,theID,theType,name)
  Handle theResource;
  short *theID;
  ResType *theType;
  char *name;
pascal short GetResAttrs(theResource)
  Handle theResource;
pascal long SizeResource(theResource)
  Handle theResource;
pascal long MaxSizeRsrc(theResource)
  Handle theResource;
pascal long RsrcMapEntry(theResource)
  Handle theResource;

/* Modifing Resources */

void SetResInfo(theResource,theID,name)
  Handle theResource;
  short theID;
  char *name;
pascal void SetResAttrs(theResource,attrs)
  Handle theResource;
  short attrs;
pascal void ChangedResource(theResource)
  Handle theResource;
void AddResource(theData,theType,theID,name)
  Handle theData;
  ResType theType;
  short theID;
  char *name;
pascal void RmveResource(theResource)
  Handle theResource;
pascal void UpdateResFile(refNum)
  short refNum;
pascal void WriteResource(theResource)
  Handle theResource;
pascal void SetResPurge(install)
  Boolean install;

/* Advanced Routines */

pascal short GetResFileAttrs(refNum)
  short refNum;
pascal void SetResFileAttrs(refNum,attrs)
  short refNum;
  short attrs;
short OpenRFPerm(fileName, vRefNum, permission)
  char *fileName;
  short vRefNum;
  short permission;
```

Description

The Resource Manager provides access to Macintosh resource files. `ResType` may be specified as a character literal (for example, `'MENU'`).

For more detailed information, see the Resource Manager chapter of *Inside Macintosh*.

Retrace—Vertical Retrace Manager

Synopsis

```
#include   <Types.h>
#include   <Retrace.h>

/* Data Types and Routines */

typedef struct VBLTask {
   struct QElem   *qLink;     /* next queue entry */
   short          qType;      /* unique id for validity check */
   ProcPtr        vblAddr;    /* address of service routine */
   short          vblCount;   /* count field for timeout */
   short          vblPhase;   /* phase to allow synchronization */
} VBLTask;
OSErr VInstall(vblTaskPtr)
   struct QElem *vblTaskPtr;
OSErr VRemove(vblTaskPtr)
   struct QElem *vblTaskPtr;
struct QHdr *GetVBLQHdr();
```

Description

The Vertical Retrace Manager schedules and performs recurrent tasks during vertical-retrace interrupts.

For more detailed information, see the Vertical Retrace Manager chapter of *Inside Macintosh.*

SANE—Standard Apple Numeric Environment routines

Synopsis

```
#include   <SANE.h>

/* Decimal Representation Constants */

#define    SIGDIGLEN      20  /* significant decimal digits */
#define    DECSTROUTLEN   80  /* max length for decimal string */

/* Decimal Formatting Styles */

#define    FLOATDECIMAL    0
#define    FIXEDDECIMAL    1

/* Exceptions */

#define    INVALID         1
#define    UNDERFLOW       2
#define    OVERFLOW        4
#define    DIVBYZERO       8
#define    INEXACT        16

/* Ordering Relations */

#define    GREATERTHAN     0
#define    LESSTHAN        1
#define    EQUALTO         2
#define    UNORDERED       3

/* Inquiry Classes */

#define    SNAN            0
#define    QNAN            1
#define    INFINITE        2
#define    ZERONUM         3
#define    NORMALNUM       4
#define    DENORMALNUM     5

/* Rounding Directions */

#define    TONEAREST       0
#define    UPWARD          1
#define    DOWNWARD        2
#define    TOWARDZERO      3

/* Rounding Precisions */

#define    EXTPRECISION    0
```

```
#define    DBLPRECISION    1
#define    FLOATPRECISION  2

/* Type Definitions */

typedef short exception;     /* sum of INVALID...INEXACT */
typedef short relop;                    /* relational operator */
typedef short numclass;                 /* inquiry class */
typedef short rounddir;                 /* rounding direction */
typedef short roundpre;                 /* rounding precision */
typedef short environment;
typedef struct decimal {
  char   sgn, unused;  /* sign 0 for +, 1 for - */
  short  exp;          /* decimal exponent */
  struct {unsigned char length, text[SIGDIGLEN], unused} sig;
                       /* significant digits */
} decimal;

typedef struct decform {
  char   style, unused;                 /* FLOATDECIMAL or FIXEDDECIMAL */
  short  digits;
} decform;

typedef void (*haltvector)();

/* Conversions Between Binary and Decimal Records */

void num2dec(f,x,d)     /* d <-- x, according to format f */
  decform *f;
  extended x;
  decimal *d;
extended dec2num(d)     /* returns d as extended */
  decimal *d;

/* Conversions Between Decimal Records and ASCII Strings */

void dec2str(f,d,s)    /* s <-- d, according to format f */
  decform *f;
  decimal *d;
  char *s;
void str2dec(s,ix,d,vp)   /* on input ix is starting index into s, */
  char *s;                /*  on output ix is one greater than index */
  short *ix,*vp;          /*  of last character of longest numeric */
  decimal *d;             /*  substring; boolean vp = "s beginning at */
                          /*  given ix is a valid numeric string or */
                          /*  a valid prefix of some numeric string" */

/* Arithmetic, Auxiliary, and Elementary Functions */

extended remainder(x,y,quo) /* IEEE remainder; quo <-- 7 low-order bits */
  extended x,y;             /*  of integer quotient x/y, */
  short *quo;               /*  -127 <= quo <= 127 */
extended rint(x)            /* round to integral value */
```

```
  extended x;
extended scalb(n,x)          /* binary scale: x * 2^n */
  short n;
  extended x;
extended logb(x)             /* binary log: */
  extended x;                /*   binary exponent of normalized x */
extended copysign(x,y)       /* y with sign of x */
  extended x,y;
extended nextfloat(x,y)      /* next float representation after */
  extended x,y;              /*  (float) x in direction of (float) y */
extended nextdouble(x,y)     /* next double representation after */
  extended x,y;              /*  (double) x in direction of (double) y */
extended nextextended(x,y)   /* next extended representation after x */
  extended x,y;              /*   in direction of y */
extended log2(x)             /* base-2 log */
  extended x;
extended log1(x)             /* log(1 + x) */
  extended x;
extended exp2(x)             /* base-2 exponential */
  extended x;
extended exp1(x)             /* exp(x) - 1 */
  extended x;
extended power(x,y)          /* general exponential: x ^ y */
  extended x,y;
extended ipower(x,i)         /* integer exponential: x ^ i */
  extended x;
  short i;
extended compound(r,n)       /* compound: (1 + r) ^ n */
  extended r,n;
extended annuity(r,n)        /* annuity: (1 - (1 + r) ^ (-n)) / r */
  extended r,n;
extended randomx(x)          /* returns next random number; updates x; */
  extended *x;               /*   x integral, 1 <= x <= 2^31 - 2 */

/* Inquiry Routines */

numclass classfloat(x) /* class of (float) x */
  extended x;
numclass classdouble(x)      /* class of (double) x */
  extended x;
numclass classcomp(x)        /* class of (comp) x */
  extended x;
numclass classextended(x)    /* class of x */
  extended x;
long signnum(x)              /* returns 0 for +, 1 for - */
  extended x;

/* Environment Access Routines */
/*  An exception variable encodes the exceptions whose sum
/*  is its value. */

void setexception(e,s)       /* clrs e flags if s is 0, sets e flags */
  exception e;               /*   otherwise; may cause halt */
  long s;
long testexception(e)        /* returns 1 if any e flag is set, */
  exception e;               /*   returns 0 otherwise */
void sethalt(e,s)            /* disables e halts if s is 0, */
  exception e;               /*   enables e halts otherwise */
  long s;
long testhalt(e)             /* returns 1 if any e halt is enabled,  */
  exception e;               /*   returns 0 otherwise */
void setround(r)             /* sets rounding direction to r */
  rounddir r;
  rounddir getround();       /* returns rounding direction */
void setprecision(p)         /* sets rounding precision to p */
  roundpre p;
roundpre getprecision();     /* returns rounding precision */
void setenvironment(e)       /* sets environment to e */
  environment e;
void getenvironment(e)       /* e <-- environment */
  environment *e;
void procentry(e)            /* e <-- environment; */
  environment *e;            /*   environment <-- IEEE default */
void procexit(e)             /* temp <-- exceptions; environment <-- e  */
  environment e;             /*   signals exceptions in temp */
haltvector gethaltvector();  /* returns halt vector */
void sethaltvector(v)        /* halt vector <-- v */
  haltvector v;

/* Comparison Routine */

relop relation(x,y)          /* returns relation such that */
  extended x,y;              /*   "x relation y" is true */

/* NaNs and Special Constants */

extended nan(c)              /* returns NaN with code c */
  unsigned char c;
extended inf();              /* infinity */
extended pi();               /* pi */
```

Description

The SANE functions `fabs`, `sqrt`, `exp`, `log`, `tan`, `sin`, `cos`, and `atan` are described in Chapter 3, "The Standard C Library."

These routines together with Apple's C language fully support the Standard Apple Numeric Environment (SANE). They provide a scrupulously conforming implementation of extended-precision IEEE Standard 754 floating-point arithmetic.

The Standard Apple Numeric Environment is documented in the *Apple Numerics Manual.*

Scrap—Scrap Manager

Synopsis

```
#include   <Types.h>
#include   <Scrap.h>

/* Type Definitions */

typedef struct ScrapStuff {
  long                  scrapSize;
  Handle                scrapHandle;
  short                 scrapCount;
  short                 scrapState;
  StringPtr             scrapName;
} ScrapStuff, *PScrapStuff;

/* Getting Desk Scrap Information */

pascal PScrapStuff InfoScrap();

/* Keeping the Desk Scrap on the Disk */

pascal long UnloadScrap();
pascal long LoadScrap();

/* Writing to the Desk Scrap */

pascal long ZeroScrap();
pascal long PutScrap(length,theType,source)
  long length;
  ResType theType;
  Ptr source;

/* Reading From the Desk Scrap */

pascal long GetScrap(hDest,theType,offset)
  Handle hDest;
  ResType theType;
  long *offset;
```

Description

The Scrap Manager provides a mechanism for cutting and pasting between applications and desk accessories.

For more detailed information, see the Scrap Manager chapter of *Inside Macintosh*.

SCSI—SCSI Manager

Synopsis

```
#include   <Types.h>
#include   <SCSI.h>

/* Transfer Instruction Operation Codes */

#define    scInc      1
#define    scNoInc    2
#define    scAdd      3
#define    scMove     4
#define    scLoop     5
#define    scNop      6
#define    scStop     7
#define    scComp     8

typedef struct SCSIInstr {
   unsigned short   scOpcode;
   unsigned long    scParam1;
   unsigned long    scParam2;
} SCSIInstr;

/* Routines */

pascal OSErr SCSIReset();
pascal OSErr SCSIReset();
pascal OSErr SCSIReset();
pascal OSErr SCSIReset();
pascal OSErr SCSIReset();
pascal OSErr SCSIReset();
pascal OSErr SCSIGet();
pascal OSErr SCSISelect(targetID)
pascal OSErr SCSIReset();
pascal OSErr SCSIReset();
   short targetID;
pascal OSErr SCSICmd(buffer, count)
   Ptr buffer;
   short count;
pascal OSErr SCSIRead(tibPtr)
   Ptr tibPtr;
pascal OSErr SCSIRBlind(tibPtr)
   Ptr tibPtr;
pascal OSErr SCSIWrite(tibPtr)
   Ptr tibPtr;
pascal OSErr SCSIWBlind(tibPtr)
   Ptr tibPtr;
pascal OSErr SCSIComplete(stat, message, wait)
   short *stat,*message;
   unsigned long wait;
pascal short SCSIStat();
```

Description The SCSI Manager controls the exchange of information between a Macintosh and peripheral devices connected through the Small Computer Standard Interface (SCSI).

For more detailed information, see the SCSI Manager chapter of *Inside Macintosh*, Volume 4.

SegLoad—Segment Loader

Synopsis

```
#include   <Types.h>
#include   <SegLoad.h>

/* Message Returned by CountAppFiles */

#define    appOpen     0  /* open the document(s) */
#define    appPrint    1  /* print the document(s) */

typedef struct AppFile {
   short                vRefNum;        /* volume reference number */
   OSType               fType;          /* file type */
   short                versNum;        /* version number */
   Str255               fName;          /* file name */
} AppFile;

/* Routines */

void CountAppFiles(message,count)
   short *message;
   short *count;
void GetAppFiles(index,theFile)
   short index;
   AppFile *theFile;
void ClrAppFiles(index)
   short index;
void GetAppParms(apName,apRefNum,apParam)
   char *apName;
   short *apRefNum;
   Handle *apParam;
pascal void UnloadSeg(routineAddr)
   Ptr routineAddr;
pascal void ExitToShell();
```

Description

The Segment Loader is the part of the Macintosh Operating System that lets you divide your application into several parts and have only some of them in memory at a time. When an application starts up, the Segment Loader also provides it with a list of files to open or print.

For more detailed information, see the Segment Loader chapter of *Inside Macintosh*.

Serial—Serial Drivers

Synopsis

```
#include   <Types.h>
#include   <Serial.h>

/* Driver Reset Information */

#define    baud300          380    /*   300 baud */
#define    baud600          189    /*   600 baud */
#define    baud1200          94    /*  1200 baud */
#define    baud1800          62    /*  1800 baud */
#define    baud2400          46    /*  2400 baud */
#define    baud3600          30    /*  3600 baud */
#define    baud4800          22    /*  4800 baud */
#define    baud7200          14    /*  7200 baud */
#define    baud9600          10    /*  9600 baud */
#define    baud19200          4    /* 19200 baud */
#define    baud57600          0    /* 57600 baud */
#define    stop10         16384    /* 1 stop bit */
#define    stop15      (-32768)    /* 1.5 stop bits */
#define    stop20      (-16384)    /* 2 stop bits */
#define    noParity           0    /* no parity */
#define    oddParity       4096    /* odd parity */
#define    evenParity     12288    /* even parity */
#define    data5              0    /* 5 data bits */
#define    data6           2048    /* 6 data bits */
#define    data7           1024    /* 7 data bits */
#define    data8           3072    /* 8 data bits */

/* Masks for Changes That Cause Events to Be Posted */

#define    ctsEvent          32    /* set if CTS change will cause event */
                                   /*  to be posted */

#define    breakEvent       128    /* set if break status change will */
                                   /*  cause event to be posted */

/* Indication That XOFF Char Was Sent */

#define    xOffWasSent       0x80

/* Indication That DTR Is Negated */

#define    dtrNegated        0x40

typedef enum {
   sPortA,                         /* modem port */
   sPortB                          /* printer port */
} SPortSel;
```

```
typedef struct SerShk {
  char                   fXOn;             /* XON/XOFF output flow control flag */
  char                   fCTS;             /* CTS hardware handshake flag */
  unsigned char          xOn;              /* XOn character */
  unsigned char          xOff;             /* XOff character */
  char                   errs;             /* errors that cause abort */
  char                   evts;             /* status changes that cause events */
  char                   fInX;             /* XOn/XOff input flow control flag */
  char                   fDTR;             /* DTR input flow control flag*/
} SerShk;

typedef struct SerStaRec {
  char                   cumErrs;          /* cumulative errors */
  char                   xOffSent;         /* XOff sent as input flow control */
  char                   rdPend;           /* read pending flag */
  char                   wrPend;           /* write pending flag */
  char                   ctsHold;          /* CTS flow control hold flag */
  char                   xOffHold;         /* XOff received as output flow
                                              control */
} SerStaRec;

/* Opening and Closing the RAM Serial Driver */

OSErr RAMSDOpen(whichPort)
  SPortSel whichPort;
void RAMSDClose(whichPort)
  SPortSel whichPort;

/* Changing Serial Driver Information */

OSErr SerReset(refNum,serConfig)
  short refNum;
  short serConfig;
OSErr SerSetBuf(refNum,serBPtr,serBLen)
  short refNum;
  Ptr serBPtr;
  short serBLen;
OSErr SerHShake(refNum,flags);
  short refNum;
  SerShk *flags;
OSErr SerSetBrk(refNum)
  short refNum;
OSErr SerClrBrk(refNum)
  short refNum;

/* Getting Serial Driver Information */

OSErr SerGetBuf(refNum,count)
  short refNum;
  long *count;
OSErr SerStatus(refNum,serSta)
  short refNum;
  SerStaRec *serSta;
```

Description

The RAM Serial Driver and the ROM Serial Driver are Macintosh device drivers for handling asynchronous serial communication between a Macintosh application and serial devices.

For more detailed information, see the Serial Drivers chapter of *Inside Macintosh*.

Sound—Sound Driver

Synopsis

```
#include   <Types.h>
#include   <Sound.h>

/* Mode Values for Synthesizers */

#define    swMode          (-1)  /* square-wave synthesizer */
#define    ftMode            1   /* four-tone synthesizer */
#define    ffMode            0   /* free-form synthesizer */

/* Free-Form Synthesizer */

typedef unsigned char FreeWave[30001];
typedef struct FFSynthRec {
   short               mode;          /* always ffMode */
   Fixed               count;         /* "sizing" factor */
   FreeWave            waveBytes;     /* waveform description */
} FFSynthRec, *FFSynthPtr;

/* Square-Wave Synthesizer */

typedef struct Tone {
   short               count;         /* frequency */
   short               amplitude;     /* amplitude, 0-255 */
   short               duration;      /* duration in ticks */
} Tone;

typedef Tone Tones[5001];
typedef struct SWSynthRec {
   short               mode;          /* always swMode */
   Tones               triplets;      /* sounds */
} SWSynthRec, *SWSynthPtr;

/* Four-Tone Synthesizer */

typedef unsigned char Wave[256];
typedef Wave *WavePtr;
typedef struct FTSoundRec {
   short               duration;      /* duration in ticks */
   Fixed               sound1Rate;    /* tone 1 cycle rate */
   long                sound1Phase;   /* tone 1 byte offset */
   Fixed               sound2Rate;    /* tone 2 cycle rate */
   long                sound2Phase;   /* tone 2 byte offset */
   Fixed               sound3Rate;    /* tone 3 cycle rate */
   long                sound3Phase;   /* tone 3 byte offset */
   Fixed               sound4Rate;    /* tone 4 cycle rate */
   long                sound4Phase;   /* tone 4 byte offset */
```

```
  WavePtr                 sound1Wave;      /* tone 1 wave form */
  WavePtr                 sound2Wave;      /* tone 2 wave form */
  WavePtr                 sound3Wave;      /* tone 3 wave form */
  WavePtr                 sound4Wave;      /* tone 4 wave form */
} FTSoundRec, *FTSndRecPtr;

typedef struct FTSynthRec {
  short                   mode;            /* always ftMode */
  FTSndRecPtr sndRec;                      /* tones to play */
} FTSynthRec, *FTSynthPtr;

/* Routines [Not in ROM] */

void StartSound(synthRec,numBytes,completionRtn)
  Ptr synthRec;
  long numBytes;
  ProcPtr completionRtn;
void StopSound();
Boolean SoundDone();
void GetSoundVol(level)
  short *level;
void SetSoundVol(level)
  short level
```

Description

The Sound Driver is a Macintosh device driver for handling sound and music generation in a Macintosh application.

For more detailed information, see the Sound Driver chapter of *Inside Macintosh*.

Strings—string conversions

Synopsis

```
#include   <Strings.h>

/* Routines */

char *c2pstr(s)
   char *s;
char *p2cstr(s)
   char *s;
```

Description

Function `c2pstr` converts `s` from a C string to a Pascal string. Function `p2cstr` converts `s` from a Pascal string to a C string. Both conversions are done in place. For convenience, `c2pstr` and `p2cstr` return `s` as their function result. Both functions will accept `nil` as their parameter and do nothing.

Pascal strings begin with a length byte. C strings are terminated by a zero byte. The macro `String` is defined in file Types.h.

TextEdit—text-editing routines

Synopsis

```
#include   <Types.h>
#include   <TextEdit.h>

/* Text justification */

#define    teJustLeft          0
#define    teJustCenter        1
#define    teJustRight       (-1)

typedef struct TERec {
  Rect              destRect;          /* destination rectangle */
  Rect              viewRect;          /* view rectangle */
  Rect              selRect;           /* select rectangle */
  short             lineHeight;        /* current font line-height */
  short             fontAscent;        /* current font ascent */
  Point             selPoint;          /* selection point (mouseLoc) */
  short             selStart;          /* selection start */
  short             selEnd;            /* selection end */
  short             active;            /* != 0 if active */
  ProcPtr           wordBreak;         /* word-break routine */
  ProcPtr           clikLoop;          /* click-loop routine */
  long              clickTime;         /* time of first click */
  short             clickLoc;          /* char. location of click */
  long              caretTime;         /* time for next caret blink */
  short             caretState;        /* on/active booleans */
  short             just;              /* fill style */
  short             teLength;          /* length of text below */
  Handle            hText;             /* handle to actual text */
  short             recalBack;         /* != 0 if recal in background */
  short             recalLines;        /* line being recalulated */
  short             clikStuff;         /* click stuff (internal) */
  short             crOnly;            /* set to -1 if CR Line breaks only */
  short             txFont;            /* text Font */
  Style             txFace;            /* text Face */
  short             txMode;            /* text Mode */
  short             txSize;            /* text Size */
  struct GrafPort   *inPort;           /* GrafPort */
  ProcPtr           highHook;          /* highlighting hook */
  ProcPtr           caretHook;         /* caret hook */
  short             nLines;            /* number of lines */
  short             lineStarts[16001]; /* line starts */
} TERec, *TEPtr, **TEHandle;

typedef char Chars[32001];

typedef Chars *CharsPtr, **CharsHandle;
```

```
/* Initialization and Allocation */

pascal void TEInit();
pascal TEHandle TENew(destRect,viewRect)
  Rect *destRect, *viewRect;
pascal void TEDispose(hTE)
  TEHandle hTE;

/* Accessing the Text of an Edit Record */

pascal void TESetText(text,length,hTE)
  Ptr text;
  long length;
  TEHandle hTE;
pascal CharsHandle TEGetText(hTE)
  TEHandle hTE;

/* Insertion Point and Selection Range */

pascal void TEIdle(hTE)
  TEHandle hTE;
void TEClick(pt,extend,hTE)
  Point *pt;
  Boolean extend;
  TEHandle hTE;
pascal void TESetSelect(selStart,selEnd,hTE)
  long selStart,selEnd;
  TEHandle hTE;
pascal void TEActivate(hTE)
  TEHandle hTE;
pascal void TEDeactivate(hTE)
  TEHandle hTE;

/* Editing */

pascal void TEKey(key,hTE)
  short key;
  TEHandle hTE;
pascal void TECut(hTE)
  TEHandle hTE;
pascal void TECopy(hTE)
  TEHandle hTE;
pascal void TEPaste(hTE)
  TEHandle hTE;
pascal void TEDelete(hTE)
  TEHandle hTE;
pascal void TEInsert(text,length,hTE)
  Ptr text;
  long length;
  TEHandle hTE;
```

```
/* Text Display and Scrolling */

pascal void TESetJust(just,hTE)
  short just;
  TEHandle hTE;
pascal void TEUpdate(rUpdate,hTE)
  Rect *rUpdate;
  TEHandle hTE;
pascal void TextBox(text,length,box,just)
  Ptr text;
  long length;
  Rect *box;
  short just;
pascal void TEScroll(dh,dv,hTE)
  short dh,dv;
  TEHandle hTE;
pascal void TESelView(hTE)
  TEHandle hTE;
pascal void TEPinScroll(dh,dv,hTE)
  short dh;
  short dv;
  TEHandle hTE;
pascal void TEAutoView(pAuto,hTE)
  Boolean pAuto;
  TEHandle hTE;

/* Scrap Handling [Not in ROM] */

OSErr TEFromScrap();
OSErr TEToScrap();
Handle TEScrapHandle();
long TEGetScrapLen();
void TESetScrapLen(length)
  long length;

/* Advanced Routines */

void SetWordBreak(wBrkProc,hTE)
  ProcPtr wBrkProc;
  TEHandle hTE;
void SetClikLoop(clikProc,hTE)
  ProcPtr clikProc;
  TEHandle hTE;
pascal void TECalText(hTE)
  TEHandle hTE;
```

User routines

```
/* Word Break Routine */

pascal Boolean MyWordBreak(text,charPos)
  Ptr text;
  short charPos;
```

```
/* Click Loop Routine */

pascal Boolean MyClikLoop();
```

Description The TextEdit package provides basic text formatting and editing.

For more detailed information, see the TextEdit chapter of *Inside Macintosh*.

Note The user routines `highHook` and `caretHook` are called with register conventions and therefore can't be C routines.

Time—Time Manager

Synopsis

```
#include   <Types.h>
#include   <OSUtils.h>
#include   <Time.h>

typedef struct TMTask {
   struct QElem   *qLink;    /* next queue entry */
   short          qType;     /* queue type */
   ProcPtr        tmAddr;    /* pointer to routine */
   short          tmCount;   /* reserved */
} TMTask;

pascal void InsTime(tmTaskPtr)
   TMTask *tmTaskPtr;
pascal void PrimeTime(tmTaskPtr, count)
   TMTask *tmTaskPtr;
   long count;
pascal void RmvTime(tmTaskPtr)
   TMTask *tmTaskPtr;
```

Description

The Time Manager is the part of the operating system that lets you schedule a routine to be executed after a given number of milliseconds have elapsed.

For more detailed information, see the Time Manager chapter of *Inside Macintosh,* Volume 4.

ToolUtils—Toolbox Utilities

Synopsis

```
#include   <Types.h>
#include   <QuickDraw.h>
#include   <ToolUtils.h>

/* Resource ID of Standard Pattern List */

#define    sysPatListID  0
#define    iBeamCursor   1    /* text selection */
#define    crossCursor   2    /* drawing graphics */
#define    plusCursor    3    /* cell selection */
#define    watchCursor   4    /* indicating long delay */

typedef struct Int64Bit {
  long                  hiLong;
  long                  loLong;
} Int64Bit;

typedef struct Cursor *CursPtr, **CursHandle;

typedef Pattern *PatPtr, **PatHandle;

/* Fixed-Point Arithmetic */

pascal Fixed FixRatio(numer,denom)
  short numer,denom;
pascal Fixed FixMul(a,b)
  Fixed a,b;
pascal short FixRound(x)
  Fixed x;

/* String Manipulation */

StringHandle NewString(theString)
  char *theString;
void SetString(h,theString)
  StringHandle h;
  char *theString;
pascal StringHandle GetString(stringID)
  short stringID;
void GetIndString(theString,strListID,index)
  char *theString;
  short strListID;
  short index;
```

```
/* Byte Manipulation */

pascal long Munger(h,offset,ptr1,len1,ptr2,len2)
  Handle h;
  long offset;
  Ptr ptr1;
  long len1;
  Ptr ptr2;
  long len2;
pascal void PackBits(srcPtr,dstPtr,srcBytes)
  Ptr *srcPtr,*dstPtr;
  short srcBytes;
pascal void UnpackBits(srcPtr,dstPtr,dstBytes)
  Ptr *srcPtr,*dstPtr;
  short dstBytes;

/* Bit Manipulation */

pascal Boolean BitTst(bytePtr,bitNum)
  Ptr bytePtr;
  long bitNum;
pascal void BitSet(bytePtr,bitNum)
  Ptr bytePtr;
  long bitNum;
pascal void BitClr(bytePtr,bitNum)
  Ptr bytePtr;
  long bitNum;

/* Logical Operations */

pascal long BitAnd(value1,value2)
  long value1,value2;
pascal long BitOr(value1,value2)
  long value1,value2;
pascal long BitXor(value1,value2)
  long value1,value2;
pascal long BitNot(value)
  long value;
pascal long BitShift(value,count)
  long value;
  short count;

/* Operations on Long Integers */

pascal short HiWord(x)
  long x;
pascal short LoWord(x)
  long x;
pascal void LongMul(a,b,dest)
  long a,b;
  Int64Bit *dest;
```

```
/* Graphics Utilities */

void ScreenRes(scrnHRes,scrnVRes)
   short *scrnHRes,*scrnVRes;
pascal Handle GetIcon(iconID)
   short iconID;
pascal void PlotIcon(theRect,theIcon)
   Rect *theRect;
   Handle theIcon;
pascal PatHandle GetPattern(patID)
   short patID;
void GetIndPattern(thePattern,patListID,index)
   Pattern thePattern;
   short patListID;
   short index;
pascal CursHandle GetCursor(cursorID)
   short cursorID;
void ShieldCursor(shieldRect,offsetPt)
   Rect *shieldRect;
   Point *offsetPt;
pascal struct Picture **GetPicture(picID)
   short picID;

/* Miscellaneous Utilities */

long DeltaPoint(ptA,ptB)
   Point *ptA,*ptB;
pascal Fixed SlopeFromAngle(angle)
   short angle;
pascal short AngleFromSlope(slope)
   Fixed slope;
```

Description

The Toolbox Utilities provide fixed-point arithmetic; string, byte, and bit manipulation; logical operations; and some graphics utilities.

For more detailed information, see the ToolBox Utilities chapter of *Inside Macintosh*.

Note

The FixMath section in this chapter describes additional fixed-point arithmetic routines.

Warning

`NewString` and `GetString` return handles to Pascal strings. `NewString`, `SetString`, and `GetIndString` take a C string as their parameter and convert it to a Pascal string before storing it in memory.

Types—common defines and types

Synopsis

```
#include   <Types.h>
#define    nil       0
#define    NULL      0
#define    noErr     0

typedef enum {false,true} Boolean;
typedef char *Ptr;
typedef Ptr *Handle;
typedef long (*ProcPtr)();
typedef ProcPtr *ProcHandle;
typedef long Fixed;
typedef long Fract;
typedef unsigned long ResType;
typedef long OSType;
typedef short OSErr;
typedef short Style;
typedef struct Point {
   short                v;
   short                h;
} Point;
typedef struct Rect {
   short                top;
   short                left;
   short                bottom;
   short                right;
} Rect;

/* Pascal String Macro */

#define String(size) struct {\
   unsigned char length; unsigned char text[size];}

/* Inside Macintosh String Definitions */

typedef String(255) Str255, *StringPtr, **StringHandle;
```

Description

These defines and types are shared by several Macintosh libraries.

The define `String` approximates Pascal strings. It creates a `struct`, not an array. Remember to use `&` when passing `structs` as parameters.

Windows—Window Manager

Synopsis

```
#include   <Types.h>
#include   <QuickDdraw.h>
#include   <Windows.h>

/* Window Definition IDs */

#define    documentProc   0
#define    dBoxProc       1
#define    plainDBox      2
#define    altDBoxProc    3
#define    noGrowDocProc  4
#define    zoomDocProc    8
#define    rDocProc      16

/* Window Class, in windowKind Field of Window Record */

#define    dialogKind     2
#define    userKind       8

/* Values Returned by FindWindow */

#define    inDesk         0
#define    inMenuBar      1
#define    inSysWindow    2
#define    inContent      3
#define    inDrag         4
#define    inGrow         5
#define    inGoAway       6
#define    inZoomIn       7
#define    inZoomOut      8

/* Axis Constraints for DragGrayRgn */

#define    noConstraint   0
#define    hAxisOnly      1
#define    vAxisOnly      2

/* Messages to Window Definition Function */

#define    wDraw          0
#define    wHit           1
#define    wCalcRgns      2
#define    wNew           3
#define    wDispose       4
#define    wGrow          5
#define    wDrawGIcon     6
```

```
/* Values Returned by Window Definition Function's Hit Routine */

#define    wNoHit         0
#define    wInContent     1
#define    wInDrag        2
#define    wInGrow        3
#define    wInGoAway      4
#define    wInZoomIn      5
#define    wInZoomOut     6

/* Resource ID of Desktop Pattern */

#define    deskPatID     16

typedef GrafPtr WindowPtr;
typedef struct WindowRecord {
  GrafPort              port;
  short                 windowKind;
  Boolean               visible;
  Boolean               hilited;
  Boolean               goAwayFlag;
  Boolean               spareFlag;
  RgnHandle             strucRgn;
  RgnHandle             contRgn;
  RgnHandle             updateRgn;
  Handle                windowDefProc;
  Handle                dataHandle;
  StringHandle          titleHandle;
  short                 titleWidth;
  struct ControlRecord **controlList;
  struct WindowRecord *nextWindow;
  PicHandle             windowPic;
  long                  refCon;
} WindowRecord, *WindowPeek;

typedef struct WStateData {
  Rect                                  userState;
  Rect                                  stdState;
} WStateData;

/* Initialization and Allocation */

pascal void InitWindows();
pascal void GetWMgrPort(wPort)
  GrafPtr *wPort;
WindowPtr NewWindow(wStorage,boundsRect,title,visible,procID,behind,
  goAwayFlag,refCon)
  Ptr wStorage;
  Rect *boundsRect;
  char *title;
  Boolean visible;
  short procID;
  WindowPtr behind;
```

```
   Boolean goAwayFlag;
   long refCon;
pascal WindowPtr GetNewWindow(windowID,wStorage,behind)
   short windowID;
   Ptr wStorage;
   WindowPtr behind;
pascal void CloseWindow(theWindow)
   WindowPtr theWindow;
pascal void DisposeWindow(theWindow)
   WindowPtr theWindow;

/* Window Display */

void SetWTitle(theWindow,title)
   WindowPtr theWindow;
   char *title;
void GetWTitle(theWindow,title)
   WindowPtr theWindow;
   char *title;
pascal void SelectWindow(theWindow)
   WindowPtr theWindow;
pascal void HideWindow(theWindow)
   WindowPtr theWindow;
pascal void ShowWindow(theWindow)
   WindowPtr theWindow;
pascal void ShowHide(theWindow,showFlag)
   WindowPtr theWindow;
   Boolean showFlag;
pascal void HiliteWindow(theWindow,fHiLite)
   WindowPtr theWindow;
   Boolean fHiLite;
pascal void BringToFront(theWindow)
   WindowPtr theWindow;
pascal void SendBehind(theWindow,behindWindow)
   WindowPtr theWindow,behindWindow;
pascal WindowPtr FrontWindow();
pascal void DrawGrowIcon(theWindow)
   WindowPtr theWindow;

/* Mouse Location */

short FindWindow(thePt,whichWindow)
   Point *thePt;
   WindowPtr *whichWindow;
Boolean TrackGoAway(theWindow,thePt)
   WindowPtr theWindow;
   Point *thePt;
Boolean TrackBox(theWindow,thePt,partCode)
   WindowPtr theWindow;
   Point *thePt;
   short partCode;
```

```
/* Window Movement and Sizing */

pascal void MoveWindow(theWindow,hGlobal,vGlobal,front)
  WindowPtr theWindow;
  short hGlobal,vGlobal;
  Boolean front;
void DragWindow(theWindow,startPt,boundsRect)
  WindowPtr theWindow;
  Point *startPt;
  Rect *boundsRect;
long GrowWindow(theWindow,startPt,sizeRect)
  WindowPtr theWindow;
  Point *startPt;
  Rect *sizeRect;
pascal void SizeWindow(theWindow,w,h,fUpdate)
  WindowPtr theWindow;
  short w,h;
  Boolean fUpdate;
pascal void ZoomWindow(theWindow,partCode,front)
  WindowPtr theWindow;
  short partCode;
  Boolean front;

/* Update Region Maintenance */

pascal void InvalRect(badRect)
  Rect *badRect;
pascal void InvalRgn(badRgn)
  RgnHandle badRgn;
pascal void ValidRect(goodRect)
  Rect *goodRect;
pascal void ValidRgn(goodRgn)
  RgnHandle goodRgn;
pascal void BeginUpdate(theWindow)
  WindowPtr theWindow;
pascal void EndUpdate(theWindow)
  WindowPtr theWindow;

/* Miscellaneous Routines */

pascal void SetWRefCon(theWindow,data)
  WindowPtr theWindow;
  long data;
pascal long GetWRefCon(theWindow)
  WindowPtr theWindow;
pascal void SetWindowPic(theWindow,pic)
  WindowPtr theWindow;
  PicHandle pic;
pascal PicHandle GetWindowPic(theWindow)
  WindowPtr theWindow;
long PinRect(theRect,thePt)
  Rect *theRect;
  Point *thePt;
```

```
long DragGrayRgn(theRgn,startPt,limitRect,slopRect,axis,actionProc)
   RgnHandle theRgn;
   Point *startPt;
   Rect *limitRect,*slopRect;
   short axis;
   ProcPtr actionProc;

/* Low-Level Routines */

pascal Boolean CheckUpdate(theEvent)
   struct EventRecord *theEvent;
pascal void ClipAbove(window)
   WindowPeek window;
pascal void SaveOld(window)
   WindowPeek window;
pascal void DrawNew(window,update)
   WindowPeek window;
   Boolean update;
pascal void PaintOne(window,clobberedRgn)
   WindowPeek window;
   RgnHandle clobberedRgn;
pascal void PaintBehind(startWindow,clobberedRgn)
   WindowPeek startWindow;
   RgnHandle clobberedRgn;
pascal void CalcVis(window)
   WindowPeek window;
pascal void CalcVisBehind(startWindow,clobberedRgn)
   WindowPeek startWindow;
   RgnHandle clobberedRgn;
```

User routines

```
pascal MyAction();
pascal long MyWindow(varCode,theWindow,message,param)
   short varCode;
   WindowPtr theWindow;
   short message;
   long param;
```

Description

The Window Manager provides routines for creating and manipulating windows.

For more detailed information, see the Window Manager chapter of *Inside Macintosh*.

Appendix A

Calling Conventions

MPW C uses two different function-calling conventions: C calling conventions and Pascal-compatible calling conventions.

C calling conventions

This section describes the normal C calling conventions. It explains how function parameters are passed, how function results are returned, and how registers are saved across function calls. This information is useful when writing calls between C and assembly language.

Parameters

Parameters to C functions are evaluated from right to left and are pushed onto the stack in the order they are evaluated. Characters, integers, and enumerated types are passed as sign-extended 32-bit values. Pointers and arrays are passed as 32-bit addresses. Types `float`, `double`, `comp`, and `extended` are passed as extended 80-bit values. Structures are also passed on the stack. Their size is rounded up to a multiple of 16 bits (2 bytes). If rounding occurs, the unused storage has the highest memory address. The caller removes the parameters from the stack.

Function results

Characters, integers, enumerated types, and pointers are returned as sign-extended 32-bit values in register D0. Types `float`, `double`, `comp`, and `extended` are returned as extended values in registers D0, D1, and A0. The low-order 16 bits of D0 contain the sign and exponent bits, register D1 contains the high-order 32 bits of the significand, and register A0 contains the low-order 32 bits of the significand. Structure values are returned as a 32-bit pointer in register D0. The pointer contains the address of a static variable into which the result is copied before returning. This implementation of structure function results is not reentrant.

Register conventions

Registers D0, D1, A0, and A1 are scratch registers that are not preserved by C functions. All other registers are preserved. Register A5 is the global frame pointer, register A6 is the local frame pointer, and register A7 is the stack pointer. Local stack frames are not necessarily created for simple functions.

Pascal-compatible calling conventions

This section describes the MPW C conventions for calling Pascal functions and for calling C functions that use Pascal-compatible calling conventions. These conventions differ from the normal C calling conventions described earlier in this appendix; they also differ from the calling conventions used by the Pascal Compiler. This section explains how function parameters are passed, how function results are returned, and how registers are saved across function calls.

Parameters

Parameters to Pascal-compatible functions are evaluated left to right and are pushed onto the stack in the order they are evaluated. Characters and enumerated types whose literal values fall in the range of types `char` or `unsigned char` are pushed as bytes. (This requires a 16-bit word on the stack. The value is in the high-order 8 bits; the low-order 8 bits are unused.) `Short` values and enumerated types whose literal values fall in the range of types `short` or `unsigned short` are passed as 16-bit values. `Int` and `long` values and the remaining enumerated types are passed as 32-bit values. Pointers and arrays are passed as 32-bit addresses. SANE types `float`, `double`, `comp`, and `extended` are passed as extended 80-bit values; this doesn't correspond to the Pascal Compiler's calling conventions, however, so a compiler warning is given. (Table 2-2 shows the recommended way to pass SANE-type values to Pascal.) Structures are also passed by value on the stack, and also cause a compiler warning. Their size is rounded up to a multiple of 16 bits (2 bytes). If rounding occurs, the unused storage has the highest memory address. The function being called removes the parameters from the stack.

Function results

Function results are returned on the stack. Stack space for the function result is reserved by the caller before pushing any parameters. Characters and enumerated types whose literal values fall in the range of types `char` or `unsigned char` are returned as bytes. (This requires a 16-bit word on the stack. The value is in the high-order 8 bits; the low-order 8 bits are unused.) `Short` values and enumerated types whose literal values fall in the range of types `short` or `unsigned short` are returned as 16-bit values. `Int` and `long` values and the remaining enumerated types are returned as 32-bit values. Pointers are returned as 32-bit addresses. Arrays may not be returned as function results. Results of type `float` are returned as 32-bit values. For structures and types `double`, `comp`, and `extended`, the caller pushes the address of a structure, `double`, `comp`, or `extended` (respectively) in the function-result location on the stack. The procedure being called stores the result at this address. The caller removes the function results from the stack.

For structure results, if the Pascal function returns a structure of greater than 4 bytes, the caller pushes a pointer to a result space before pushing any results. If the structure is 4 bytes or less, the caller reserves 2 or 4 bytes on the stack for it.

Register conventions

Registers D0, D1, D2, A0, and A1 are scratch registers. Scratch registers are not preserved by Pascal-compatible functions. All other registers are preserved. Register A5 is the global frame pointer, register A6 is the local frame pointer, and register A7 is the stack pointer.

Appendix B

Files Supplied With MPW C

MPW C is intended for use with the Macintosh Programmer's Workshop. The files listed below are on the two MPW C release disks: the first disk contains the C Compiler, and the second disk contains sample programs, the Standard C Library, and the Macintosh Interface Libraries. These files may be used directly from the release disks or copied onto a hard disk.

Disk C1: contains a single file, the Green Hills Software C Compiler for Macintosh.

Disk C2: contains files in three directories. Directory CExamples: contains instructions, a make file, and source for the example programs. CIncludes: contains header files for use with the Standard C Library and Macintosh Interface Libraries. CLibraries: contains library object files.

C Compiler (disk C1)

Filename	Comments
C	MPW C Compiler

C Compiler files (disk C2:CExamples)

Filename	Comments
Instructions.c	instructions for building examples
MakeFile.c	make file for building examples
Sample.c	source for Sample application
Sample.r	resource specifications for Sample application

Count.c	source for Count tool
Stubs.c	source for dummy library routines
Memory.c	source for Memory desk accessory
Memory.r	resource specifications for Memory desk accessory

Libraries (disk C2:CIncludes)

Filename	Comments
AppleTalk.h	AppleTalk header file
Controls.h	Control Manager header file
CType.h	character types header file
Desk.h	Desk Manager header file
Devices.h	Device Manager header file
Dialogs.h	Dialog Manager header file
DiskInit.h	Disk Initialization header file
Disks.h	Disk Driver header file
ErrNo.h	Standard C Library error numbers
Errors.h	Macintosh Interface Libraries error numbers
Events.h	Toolbox Event Manager header file
FCntl.h	file controls header file
Files.h	File Manager header file
FixMath.h	Fixed Point Math header file
Fonts.h	Font Manager header file
Graf3D.h	Graf3D header file
IOCtl.h	I/O Control header file
Lists.h	List Manager header file
Math.h	mathematical functions header file
Memory.h	Memory Manager header file
Menus.h	Menu Manager header file
OSEvents.h	Operating System Event Manager header file
OSUtils.h	Operating System Utilities header file
Packages.h	Packages header file
Printing.h	Print Manager header file
QuickDraw.h	QuickDraw header file
Resources.h	Resource Manager header file
Retrace.h	Vertical Retrace header file
SANE.h	SANE header file
Scrap.h	Scrap Manager header file
SCSI.h	SCSI Manager header file
SegLoad.h	Segment Loader header file
Serial.h	Serial Driver header file
SetJmp.h	setjmp header file
Signal.h	signal handler header file
Sound.h	Sound Driver header file
StdIO.h	Standard I/O header file
Strings.h	string conversion header file

TextEdit.h	TextEdit header file
Time.h	Time Manager header file
ToolUtils.h	Toolbox Utilities header file
Types.h	common types header file
Values.h	arithmetic values header file
VarArgs.h	variable argument list header file
Windows.h	Window Manager header file

Object files (disk C2:CLibraries)

Filename	Comments
CInterface.o	C Macintosh Interface Libraries
CRuntime.o	C runtime library
CSANELib.o	C SANE library
Math.o	mathematical functions library
StdCLib.o	Standard C Library

Appendix C

The Library Index

The Library Index contains an index entry for every define, type, enumeration literal, global variable, macro, and function defined in the Standard C Library and the Macintosh Interface Libraries. The manual pages are organized alphabetically within their chapter with one exception: the manual page "Error Numbers" in the Standard C Library chapter appears first.

- Column 1 of the Library Index contains an alphabetical list of the index entries.
- Column 2 specifies the type of declaration—for example, "`define`"—for the index entry.
- Column 3 contains the name of the manual page on which documentation for the index entry can be found.
- "(C)" following the manual page—for example, "`printf(C)`"—means look in Chapter 3, "The Standard C Library."
- Nothing following the manual page—for example, "`AppleTalk`"—means look in Chapter 4, "The Macintosh Interface Libraries."

Identifier	Type	Manual page
abbrevDate	literal	Packages
ABCallType	type	AppleTalk
abortErr	define	Errors
ABProtoType	type	AppleTalk
abs	function	abs(C)
acos	function	trig(C)
activateEvt	define	Events
activeFlag	define	Events
activMask	define	Events
AddDrive	function	Files
AddPt	function	Quickdraw
AddrBlock	type	AppleTalk
addRefFailed	define	Errors
addResFailed	define	Errors
AddResMenu	function	Menus
AddResource	function	Resources
Alert	function	Dialogs
AlertTemplate	type	Dialogs
AlertTHndl	type	Dialogs
AlertTPtr	type	Dialogs
Allocate	function	Files
alphaLock	define	Events
altDBoxProc	define	Windows
AngleFromSlope	function	ToolUtils
annuity	function	SANE
app1Evt	define	Events
app1Mask	define	Events
app2Evt	define	Events
app2Mask	define	Events
app3Evt	define	Events
app3Mask	define	Events
app4Evt	define	Events
app4Mask	define	Events
AppendMenu	function	Menus
AppFile	type	SegLoad
appleMark	define	Fonts
applFont	define	Fonts
ApplicZone	function	Memory
appOpen	define	SegLoad
appPrint	define	SegLoad
asin	function	trig(C)
atan	function	trig(C)
atan2	function	trig(C)
ATATPRec	type	AppleTalk
ATATPRecHandle	type	AppleTalk
ATATPRecPtr	type	AppleTalk
ATDDPRec	type	AppleTalk
ATDDPRecHandle	type	AppleTalk
ATDDPRecPtr	type	AppleTalk
athens	define	Fonts
ATLAPRec	type	AppleTalk
ATLAPRecHandle	type	AppleTalk
ATLAPRecPtr	type	AppleTalk
ATNBPRec	type	AppleTalk
ATNBPRecHandle	type	AppleTalk
ATNBPRecPtr	type	AppleTalk
atof	function	atof(C)
atoi	function	atoi(C)
atol	function	atoi(C)
ATPAddRsp	function	AppleTalk
atpBadRsp	define	AppleTalk
ATPCloseSocket	function	AppleTalk
ATPGetRequest	function	AppleTalk
atpLenErr	define	Errors
ATPLoad	function	AppleTalk
ATPOpenSocket	function	AppleTalk
atpProto	literal	AppleTalk
ATPReqCancel	function	AppleTalk

Identifier	Type	Manual page
ATPRequest	function	AppleTalk
ATPResponse	function	AppleTalk
ATPRspCancel	function	AppleTalk
atpSize	define	AppleTalk
ATPSndRequest	function	AppleTalk
ATPSndRsp	function	AppleTalk
ATPUnLoad	function	AppleTalk
autoKey	define	Events
autoKeyMask	define	Events
autoTrack	define	Controls
BackColor	function	Quickdraw
BackPat	function	Quickdraw
badATPSkt	define	AppleTalk
badBtSlpErr	define	Errors
badBuffNum	define	AppleTalk
badCksmErr	define	Errors
badDBtSlp	define	Errors
badDCksum	define	Errors
badMDBErr	define	Errors
badMovErr	define	Errors
badUnitErr	define	Errors
baud1200	define	Serial
baud1800	define	Serial
baud19200	define	Serial
baud2400	define	Serial
baud300	define	Serial
baud3600	define	Serial
baud4800	define	Serial
baud57600	define	Serial
baud600	define	Serial
baud7200	define	Serial
baud9600	define	Serial
bdConv	define	Packages
bDevCItoh	define	Printing

Identifier	Type	Manual page
bDevLaser	define	Printing
bdNamErr	define	Errors
bDraftLoop	define	Printing
BDSElement	type	AppleTalk
BDSPtr	type	AppleTalk
BDSType	type	AppleTalk
BeginUpdate	function	Windows
BitAnd	function	ToolUtils
BitClr	function	ToolUtils
BitMap	type	Quickdraw
BitMapType	type	AppleTalk
BitNot	function	ToolUtils
BitOr	function	ToolUtils
Bits16	type	Quickdraw
BitSet	function	ToolUtils
BitShift	function	ToolUtils
BitTst	function	ToolUtils
BitXor	function	ToolUtils
blackBit	define	Quickdraw
blackColor	define	Quickdraw
BlockMove	function	Memory
blueBit	define	Quickdraw
blueColor	define	Quickdraw
bold	define	Quickdraw
Boolean	type	Types
breakEvent	define	Serial
breakRecd	define	Errors
BringToFront	function	Windows
bSpoolLoop	define	Printing
btnCtrl	define	Dialogs
btnState	define	Events
buf2SmallErr	define	Errors
BUFSIZ	define	setbuf(C)
Button	function	Events

Identifier	Type	Manual page
buttonMsg	define	Devices
c2pstr	function	Strings
cairo	define	Fonts
calcCRgns	define	Controls
CalcMask	function	Quickdraw
CalcMenuSize	function	Menus
CalcVis	function	Windows
CalcVisBehind	function	Windows
calloc	function	malloc(C)
cancelButton	define	Dialogs
cantStepErr	define	Errors
CautionAlert	function	Dialogs
cbNotFound	define	AppleTalk
ceil	function	floor(C)
Cell	type	Lists
century	define	Packages
cfree	function	malloc(C)
ChangedResource	function	Resources
charCodeMask	define	Events
Chars	type	TextEdit
CharsHandle	type	TextEdit
CharsPtr	type	TextEdit
CharWidth	function	Quickdraw
checkBoxProc	define	Controls
CheckItem	function	Menus
checkMark	define	Fonts
CheckUpdate	function	Windows
chkCtrl	define	Dialogs
chooserID	define	Devices
ckSumErr	define	Errors
classcomp	function	SANE
classdouble	function	SANE
classextended	function	SANE
classfloat	function	SANE

Identifier	Type	Manual page
clearerr	macro	ferror(C)
ClearMenuBar	function	Menus
Clip3D	function	Graf3D
ClipAbove	function	Windows
ClipRect	function	Quickdraw
clkRdErr	define	Errors
clkWrErr	define	Errors
close	function	close(C)
CloseDeskAcc	function	Desk
CloseDialog	function	Dialogs
CloseDriver	function	Devices
ClosePicture	function	Quickdraw
ClosePoly	function	Quickdraw
ClosePort	function	Quickdraw
CloseResFile	function	Resources
CloseRgn	function	Quickdraw
CloseWindow	function	Windows
ClrAppFiles	function	SegLoad
cmdKey	define	Events
CMovePBRec	type	Files
CntrlParam	type	Devices
ColorBit	function	Quickdraw
commandMark	define	Fonts
CompactMem	function	Memory
compound	function	SANE
condense	define	Quickdraw
Control	function	Devices
controlErr	define	Errors
ControlHandle	type	Controls
ControlPtr	type	Controls
ControlRecord	type	Controls
CopyBits	function	Quickdraw
CopyMask	function	Quickdraw
CopyRgn	function	Quickdraw

Identifier	Type	Manual page
copysign	function	SANE
corErr	define	Errors
cos	function	trig(C)
cosh	function	sinh(C)
CouldAlert	function	Dialogs
CouldDialog	function	Dialogs
Count1Resources	function	Resources
Count1Types	function	Resources
CountAppFiles	function	SegLoad
CountMItems	function	Menus
CountResources	function	Resources
CountTypes	function	Resources
courier	define	Fonts
creat	function	creat(C)
Create	function	Files
CreateResFile	function	Resources
crossCursor	define	ToolUtils
ctnIcon	define	Dialogs
ctrlItem	define	Dialogs
ctsEvent	define	Serial
CurResFile	function	Resources
currLeadingZ	define	Packages
currNegSym	define	Packages
currSymLead	define	Packages
currTrailingZ	define	Packages
CursHandle	type	ToolUtils
Cursor	type	Quickdraw
CursPtr	type	ToolUtils
cyanBit	define	Quickdraw
cyanColor	define	Quickdraw
data5	define	Serial
data6	define	Serial
data7	define	Serial
data8	define	Serial

Identifier	Type	Manual page
dataVerErr	define	Errors
Date2Secs	function	OSUtils
DateForm	type	Packages
DateTimeRec	type	OSUtils
dayLdingZ	define	Packages
DBLPRECISION	define	SANE
dBoxProc	define	Windows
DCtlEntry	type	Devices
DCtlHandle	type	Devices
DCtlPtr	type	Devices
DDPCloseSocket	function	AppleTalk
ddpLenErr	define	Errors
DDPOpenSocket	function	AppleTalk
ddpProto	literal	AppleTalk
DDPRdCancel	function	AppleTalk
DDPRead	function	AppleTalk
ddpSize	define	AppleTalk
ddpSktErr	define	Errors
DDPWrite	function	AppleTalk
DDTMAC	define	SCSI
dec2num	function	SANE
dec2str	function	SANE
decform	type	SANE
decimal	type	SANE
DECSTROUTLEN	define	SANE
Delay	function	OSUtils
DeleteMenu	function	Menus
DelMenuItem	function	Menus
DeltaPoint	function	ToolUtils
DENORMALNUM	define	SANE
Dequeue	function	OSUtils
deSelect	define	Desk
deselectMsg	define	Devices
deskPatID	define	Windows

Identifier	Type	Manual page
DetachResource	function	Resources
Device	function	Devices
dialogKind	define	Windows
DialogPeek	type	Dialogs
DialogPtr	type	Dialogs
DialogRecord	type	Dialogs
DialogSelect	function	Dialogs
DialogTemplate	type	Dialogs
DialogTHndl	type	Dialogs
DialogTPtr	type	Dialogs
diamondMark	define	Fonts
DIBadMount	function	Packages
DiffRgn	function	Quickdraw
DIFormat	function	Packages
DILoad	function	Packages
DInfo	type	Files
dInstErr	define	Errors
dirFulErr	define	Errors
DirInfo	type	Files
dirNFErr	define	Errors
DisableItem	function	Menus
DiskEject	function	disks
diskEvt	define	Events
diskMask	define	Events
dispCntl	define	Controls
DisposDialog	function	Dialogs
DisposeControl	function	Controls
DisposeMenu	function	Menus
DisposeRgn	function	Quickdraw
DisposeWindow	function	Windows
DisposHandle	function	Memory
DisposPtr	function	Memory
DIUnLoad	function	Packages
DIVBYZERO	define	SANE

Identifier	Type	Manual page
DIVerify	function	Packages
DIZero	function	Packages
DlgCopy	function	Dialogs
DlgCut	function	Dialogs
DlgDelete	function	Dialogs
DlgPaste	function	Dialogs
dmy	define	Packages
documentProc	define	Windows
DOWNWARD	define	SANE
dragCntl	define	Controls
DragControl	function	Controls
DragGrayRgn	function	Windows
DragWindow	function	Windows
Draw1Control	function	Controls
DrawChar	function	Quickdraw
drawCntl	define	Controls
DrawControls	function	Controls
DrawDialog	function	Dialogs
DrawGrowIcon	function	Windows
DrawMenuBar	function	Menus
DrawNew	function	Windows
DrawPicture	function	Quickdraw
DrawString	function	Quickdraw
DrawText	function	Quickdraw
dRemoveErr	define	Errors
DriveKind	type	disks
driverEvt	define	Events
driverMask	define	Events
DriveStatus	function	disks
DrvQEl	type	Files
DrvQEl1	type	Files
DrvQElPtr	type	Files
drvQType	literal	OSUtils
DrvStsHard20	type	disks

Identifier	Type	Manual page
DrvStsSory	type	disks
dsAddressErr	define	Errors
dsBusErr	define	Errors
dsChkErr	define	Errors
dsCoreErr	define	Errors
dsFPErr	define	Errors
dsFSErr	define	Errors
dsIllInstErr	define	Errors
dsIOCoreErr	define	Errors
dsIrqErr	define	Errors
dskFulErr	define	Errors
dskInit	define	Packages
dsLineAErr	define	Errors
dsLineFErr	define	Errors
dsLoadErr	define	Errors
dsMemFullErr	define	Errors
dsMiscErr	define	Errors
dsNoPackErr	define	Errors
dsNotThe1	define	Errors
dsOvflowErr	define	Errors
dsPrivErr	define	Errors
dsReinsert	define	Errors
dsStknHeap	define	Errors
dsSysErr	define	Errors
dsTraceErr	define	Errors
dsZeroDivErr	define	Errors
dummyType	literal	OSUtils
dup	function	dup(C)
dupFNErr	define	Errors
DXInfo	type	Files
E2BIG	define	errorintro(C)
EACCES	define	errorintro(C)
EBADF	define	errorintro(C)
ecvt	function	ecvt(C)
editText	define	Dialogs
EEXIST	define	errorintro(C)
EINVAL	define	errorintro(C)
EIO	define	errorintro(C)
EISDIR	define	errorintro(C)
Eject	function	Files
EMFILE	define	errorintro(C)
EMLINK	define	errorintro(C)
EmptyHandle	function	Memory
EmptyRect	function	Quickdraw
EmptyRgn	function	Quickdraw
EnableItem	function	Menus
EndUpdate	function	Windows
ENFILE	define	errorintro(C)
ENODEV	define	errorintro(C)
ENOENT	define	errorintro(C)
ENOMEM	define	errorintro(C)
ENORSRC	define	errorintro(C)
ENOSPC	define	errorintro(C)
ENOTDIR	define	errorintro(C)
Enqueue	function	OSUtils
EntityName	type	AppleTalk
EntityPtr	type	AppleTalk
environment	type	SANE
Environs	function	OSUtils
ENXIO	define	errorintro(C)
EOF	define	stdio(C)
eofErr	define	Errors
EqualPt	function	Quickdraw
EqualRect	function	Quickdraw
EqualRgn	function	Quickdraw
EqualString	function	OSUtils
EQUALTO	define	SANE
erase	literal	Quickdraw

Identifier	Type	Manual page
EraseArc	function	Quickdraw
EraseOval	function	Quickdraw
ErasePoly	function	Quickdraw
EraseRect	function	Quickdraw
EraseRgn	function	Quickdraw
EraseRoundRect	function	Quickdraw
EROFS	define	errorintro(C)
errno	int	errorintro(C)
ErrorSound	function	Dialogs
ESPIPE	define	errorintro(C)
evenParity	define	Serial
EventAvail	function	Events
EventRecord	type	Events
everyEvent	define	Events
EvQEl	type	OSEvents
evtNotEnb	define	Errors
evType	literal	OSUtils
exception	type	SANE
excessCollsns	define	Errors
exit	function	exit(C)
_exit	function	exit(C)
ExitToShell	function	SegLoad
exp	function	exp(C)
exp1	function	SANE
exp2	function	SANE
expand	define	Quickdraw
extFSErr	define	Errors
EXTPRECISION	define	SANE
extractErr	define	Errors
fabs	function	floor(C)
faccess	function	faccess(C)
false	literal	Types
FamRec	type	Fonts
fBsyErr	define	Errors

Identifier	Type	Manual page
fclose	function	fclose(C)
fcntl	function	fcntl(C)
FCPBRec	type	Files
fcvt	function	ecvt(C)
F_DELETE	define	faccess(C)
fDesktop	define	Files
fDisk	define	Files
fdopen	function	fopen(C)
F_DUPFD	define	fcntl(C)
feedCut	literal	Printing
feedFanfold	literal	Printing
feedMechCut	literal	Printing
feedOther	literal	Printing
feof	macro	ferror(C)
ferror	macro	ferror(C)
fflush	function	fclose(C)
ffMode	define	Sound
FFSynthRec	type	Sound
fgetc	function	getc(C)
fgets	function	gets(C)
F_GFONTINFO	define	faccess(C)
F_GPRINTREC	define	faccess(C)
F_GTABINFO	define	faccess(C)
fHasBundle	define	Files
FILE	type	stdio(C)
fileno	macro	ferror(C)
FileParam	type	Files
fill	literal	Quickdraw
FillArc	function	Quickdraw
fillList	define	Desk
fillListMsg	define	Devices
FillOval	function	Quickdraw
FillPoly	function	Quickdraw
FillRect	function	Quickdraw

Identifier	Type	Manual page
FillRgn	function	Quickdraw
FillRoundRect	function	Quickdraw
FindControl	function	Controls
FindDItem	function	Dialogs
FindWindow	function	Windows
FInfo	type	Files
FInitQueue	function	Files
fInvisible	define	Files
FIOBUFSIZE	define	ioctl(C)
FIODUPFD	define	ioctl(C)
FIOFNAME	define	ioctl(C)
FIOINTERACTIVE	define	ioctl(C)
FIOLSEEK	define	ioctl(C)
FIOREFNUM	define	ioctl(C)
FIOSETEOF	define	ioctl(C)
firstDskErr	define	Errors
Fix2Frac	function	FixMath
Fix2Long	function	FixMath
Fix2X	function	FixMath
FixAtan2	function	FixMath
FixDiv	function	FixMath
Fixed	type	Types
FIXEDDECIMAL	define	SANE
fixedFont	define	Fonts
FixMul	function	ToolUtils
FixRatio	function	ToolUtils
FixRound	function	ToolUtils
FlashMenuBar	function	Menus
fLckdErr	define	Errors
FLOATDECIMAL	define	SANE
FLOATPRECISION	define	SANE
floor	function	floor(C)
flPoint	define	Packages
FlushEvents	function	OSEvents

Identifier	Type	Manual page
FlushVol	function	Files
FMInput	type	Fonts
fmod	function	floor(C)
FMOutPtr	type	Fonts
FMOutput	type	Fonts
FmtDefaults	define	DiskInit
fnfErr	define	Errors
fnOpnErr	define	Errors
fOnDesk	define	Files
fontDecError	define	Errors
FontInfo	type	Quickdraw
FontRec	type	Fonts
fontSubErr	define	Errors
fontWid	define	Fonts
F_OPEN	define	faccess(C)
fopen	function	fopen(C)
ForeColor	function	Quickdraw
fprintf	function	printf(C)
fputc	function	putc(C)
fputs	function	puts(C)
Frac2Fix	function	FixMath
Frac2X	function	FixMath
FracCos	function	FixMath
FracDiv	function	FixMath
FracMul	function	FixMath
FracSin	function	FixMath
FracSqrt	function	FixMath
frame	literal	Quickdraw
FrameArc	function	Quickdraw
FrameOval	function	Quickdraw
FramePoly	function	Quickdraw
FrameRect	function	Quickdraw
FrameRgn	function	Quickdraw
FrameRoundRect	function	Quickdraw

Identifier	Type	Manual page
framingErr	define	Errors
fread	function	fread(C)
free	function	malloc(C)
FreeAlert	function	Dialogs
FreeDialog	function	Dialogs
FreeMem	function	Memory
FreeWave	type	Sound
F_RENAME	define	faccess(C)
freopen	function	fopen(C)
frexp	function	frexp(C)
FrontWindow	function	Windows
fsAtMark	define	disks
fsAtMark	define	Files
fscanf	function	scanf(C)
FSClose	function	Files
fsCurPerm	define	Files
FSDelete	function	Files
fsDSIntErr	define	Errors
fseek	function	fseek(C)
F_SFONTINFO	define	faccess(C)
fsFromLEOF	define	Files
fsFromMark	define	disks
fsFromMark	define	Files
fsFromStart	define	disks
fsFromStart	define	Files
FSOpen	function	Files
F_SPRINTREC	define	faccess(C)
fsQType	literal	OSUtils
fsRdPerm	define	Files
fsRdWrPerm	define	Files
fsRdWrShPerm	define	Files
FSRead	function	Files
fsRnErr	define	Errors
F_STABINFO	define	faccess(C)

Identifier	Type	Manual page
FSWrite	function	Files
fsWrPerm	define	Files
ftell	function	fseek(C)
ftMode	define	Sound
fTrash	define	Files
fwrite	function	fread(C)
fxdFntH	define	Fonts
fxdFntHW	define	Fonts
fxdFntW	define	Fonts
FXInfo	type	Files
geneva	define	Fonts
Get1IndResource	function	Resources
Get1IndType	function	Resources
Get1NamedResource	function	Resources
Get1Resource	function	Resources
GetAlrtStage	function	Dialogs
GetAppFiles	function	SegLoad
GetApplLimit	function	Memory
GetAppParms	function	SegLoad
getc	macro	getc(C)
getCancel	define	Packages
GetCaretTime	function	Events
getchar	macro	getc(C)
GetClip	function	Quickdraw
GetCRefCon	function	Controls
GetCTitle	function	Controls
GetCtlAction	function	Controls
GetCtlMax	function	Controls
GetCtlMin	function	Controls
GetCtlValue	function	Controls
GetCursor	function	ToolUtils
GetDateTime	function	OSUtils
GetDblTime	function	Events
GetDCtlEntry	function	Devices

Identifier	Type	Manual page
GetDItem	function	Dialogs
getDlgID	define	Packages
getDrive	define	Packages
GetDrvQHdr	function	Files
getEject	define	Packages
getenv	function	getenv(C)
getenvironment	function	SANE
GetEOF	function	Files
GetEvQHdr	function	OSEvents
GetFInfo	function	Files
GetFontInfo	function	Quickdraw
GetFPos	function	Files
GetFSQHdr	function	Files
gethaltvector	function	SANE
GetHandleSize	function	Memory
GetIcon	function	ToolUtils
GetIndPattern	function	ToolUtils
GetIndResource	function	Resources
GetIndString	function	ToolUtils
GetIndType	function	Resources
GetItem	function	Menus
GetItemIcon	function	Menus
GetItemMark	function	Menus
GetItemStyle	function	Menus
GetIText	function	Dialogs
GetKeys	function	Events
GetMenu	function	Menus
GetMenuBar	function	Menus
GetMHandle	function	Menus
GetMouse	function	Events
GetNamedResource	function	Resources
GetNewControl	function	Controls
GetNewDialog	function	Dialogs
GetNewMBar	function	Menus

Identifier	Type	Manual page
GetNewWindow	function	Windows
GetNextEvent	function	Events
getNmList	define	Packages
GetNodeAddress	function	AppleTalk
getOpen	define	Packages
GetOSEvent	function	OSEvents
GetPattern	function	ToolUtils
GetPen	function	Quickdraw
GetPenState	function	Quickdraw
GetPicture	function	ToolUtils
GetPixel	function	Quickdraw
GetPort	function	Quickdraw
GetPort3D	function	Graf3D
getprecision	function	SANE
GetPtrSize	function	Memory
GetResAttrs	function	Resources
GetResFileAttrs	function	Resources
GetResInfo	function	Resources
GetResource	function	Resources
getround	function	SANE
gets	function	gets(C)
GetScrap	function	Scrap
getScroll	define	Packages
getSel	define	Desk
getSelMsg	define	Devices
GetString	function	ToolUtils
GetSysPPtr	function	OSUtils
GetTime	function	OSUtils
GetTrapAddress	function	OSUtils
GetVBLQHdr	function	Retrace
GetVCBQHdr	function	Files
GetVInfo	function	Files
GetVol	function	Files
GetVRefNum	function	Files

Identifier	Type	Manual page	Identifier	Type	Manual page
getw	function	getc(C)	HidePen	function	Quickdraw
GetWindowPic	function	Windows	HideWindow	function	Windows
GetWMgrPort	function	Windows	HiliteControl	function	Controls
GetWRefCon	function	Windows	HiliteMenu	function	Menus
GetWTitle	function	Windows	HiliteWindow	function	Windows
GetZone	function	Memory	HIOParam	type	Files
gfpErr	define	Errors	HiWord	function	ToolUtils
GlobalToLocal	function	Quickdraw	HLock	function	Memory
GrafDevice	function	Quickdraw	HNoPurge	function	Memory
GrafPort	type	Quickdraw	HomeResFile	function	Resources
GrafPtr	type	Quickdraw	HPurge	function	Memory
GrafVerb	type	Quickdraw	hrLeadingZ	define	Packages
GREATERTHAN	define	SANE	HSetRBit	function	Memory
greenBit	define	Quickdraw	HSetState	function	Memory
greenColor	define	Quickdraw	HUnlock	function	Memory
GrowWindow	function	Windows	HVolumeParam	type	Files
GZSaveHnd	function	Memory	hwOverrunErr	define	Errors
haltvector	type	SANE	hypot	function	hypot(C)
HandAndHand	function	OSUtils	iBeamCursor	define	ToolUtils
Handle	type	Types	iconItem	define	Dialogs
HandleZone	function	Memory	Identity	function	Graf3D
HandToHand	function	OSUtils	iIOAbort	define	Printing
hard20	literal	disks	iMemFullErr	define	Printing
hAxisOnly	define	Controls	inButton	define	Controls
hAxisOnly	define	Windows	inCheckbox	define	Controls
HClrRBit	function	Memory	inContent	define	Windows
helvetica	define	Fonts	inDesk	define	Windows
HFileInfo	type	Files	index	function	string(C)
HFileParam	type	Files	inDownButton	define	Controls
HFSDefaults	type	DiskInit	inDrag	define	Windows
HGetState	function	Memory	INEXACT	define	SANE
HideControl	function	Controls	inf	function	SANE
HideCursor	function	Quickdraw	INFINITE	define	SANE
HideDItem	function	Dialogs	InfoScrap	function	Scrap

Identifier	Type	Manual page
inGoAway	define	Windows
inGrow	define	Windows
InitAllPacks	function	Packages
InitApplZone	function	Memory
initCntl	define	Controls
InitCursor	function	Quickdraw
InitDialogs	function	Dialogs
InitGraf	function	Quickdraw
InitGrf3D	function	Graf3D
initIWMErr	define	Errors
InitMenus	function	Menus
InitPack	function	Packages
InitPort	function	Quickdraw
InitResources	function	Resources
InitUtil	function	OSUtils
InitWindows	function	Windows
InitZone	function	Memory
inMenuBar	define	Windows
inPageDown	define	Controls
inPageUp	define	Controls
InsertMenu	function	Menus
InsertResMenu	function	Menus
InsetRect	function	Quickdraw
InsetRgn	function	Quickdraw
InsMenuItem	function	Menus
InsTime	function	Time
inSysWindow	define	Windows
Int64Bit	type	ToolUtils
inThumb	define	Controls
Intl0Hndl	type	Packages
Intl0Ptr	type	Packages
Intl0Rec	type	Packages
Intl1Hndl	type	Packages
Intl1Ptr	type	Packages

Identifier	Type	Manual page
Intl1Rec	type	Packages
intUtil	define	Packages
inUpButton	define	Controls
INVALID	define	SANE
InvalRect	function	Windows
InvalRgn	function	Windows
inverseBit	define	Quickdraw
invert	literal	Quickdraw
InvertArc	function	Quickdraw
InvertOval	function	Quickdraw
InvertPoly	function	Quickdraw
InvertRect	function	Quickdraw
InvertRgn	function	Quickdraw
InvertRoundRect	function	Quickdraw
inZoomIn	define	Windows
inZoomOut	define	Windows
ioctl	function	ioctl(C)
ioErr	define	Errors
_IOFBF	define	setbuf(C)
_IOLBF	define	setbuf(C)
_IONBF	define	setbuf(C)
IOParam	type	Files
ioQType	literal	OSUtils
iPFMaxPgs	define	Printing
ipower	function	SANE
iPrAbort	define	Printing
iPrBitsCtl	define	Printing
iPrDevCtl	define	Printing
iPrDrvrRef	define	Printing
iPrIOCtl	define	Printing
iPrPgFract	define	Printing
iPrSavPFil	define	Printing
isalnum	macro	ctype(C)
isalpha	macro	ctype(C)

Identifier	Type	Manual page
isascii	macro	ctype(C)
IsATPOpen	function	AppleTalk
iscntrl	macro	ctype(C)
IsDialogEvent	function	Dialogs
isdigit	macro	ctype(C)
isgraph	macro	ctype(C)
islower	macro	ctype(C)
IsMPPOpen	function	AppleTalk
isprint	macro	ctype(C)
ispunct	macro	ctype(C)
isspace	macro	ctype(C)
isupper	macro	ctype(C)
isxdigit	macro	ctype(C)
italic	define	Quickdraw
itemDisable	define	Dialogs
IUCompString	function	Packages
IUDatePString	function	Packages
IUDateString	function	Packages
IUEqualString	function	Packages
IUGetIntl	function	Packages
IUMagIDString	function	Packages
IUMagString	function	Packages
IUMetric	function	Packages
IUSetIntl	function	Packages
IUTimePString	function	Packages
IUTimeString	function	Packages
jmp_buf	type	setjmp(C)
keyCodeMask	define	Events
keyDown	define	Events
keyDownMask	define	Events
KeyMap	type	Events
keyUp	define	Events
keyUpMask	define	Events
KillControls	function	Controls

Identifier	Type	Manual page
KillIO	function	Devices
KillPicture	function	Quickdraw
KillPoly	function	Quickdraw
LActivate	function	Lists
LAddColumn	function	Lists
LAddRow	function	Lists
LAddToCell	function	Lists
LAPAdrBlock	type	AppleTalk
LAPCloseProtocol	function	AppleTalk
LAPOpenProtocol	function	AppleTalk
LAPProtErr	define	Errors
lapProto	literal	AppleTalk
LAPRead	function	AppleTalk
lapSize	define	AppleTalk
LAPWrite	function	AppleTalk
lastDskErr	define	Errors
LAutoScroll	function	Lists
LCellSize	function	Lists
LClick	function	Lists
lCloseMsg	define	Lists
LClrCell	function	Lists
LDelColumn	function	Lists
LDelRow	function	Lists
ldexp	function	frexp(C)
LDispose	function	Lists
LDoDraw	function	Lists
lDoHAutoscroll	define	Lists
lDoVAutoscroll	define	Lists
LDraw	function	Lists
lDrawMsg	define	Lists
LESSTHAN	define	SANE
lExtendDrag	define	Lists
LFind	function	Lists
LGetCell	function	Lists

Identifier	Type	Manual page
LGetSelect	function	Lists
lHiliteMsg	define	Lists
Line	function	Quickdraw
Line2D	function	Graf3D
Line3D	function	Graf3D
LineTo	function	Quickdraw
LineTo2D	function	Graf3D
LineTo3D	function	Graf3D
lInitMsg	define	Lists
ListHandle	type	Lists
listMgr	define	Packages
ListPtr	type	Lists
ListRec	type	Lists
LLastClick	function	Lists
LNew	function	Lists
LNextCell	function	Lists
lNoDisjoint	define	Lists
lNoExtend	define	Lists
lNoNilHilite	define	Lists
lNoRect	define	Lists
LoadResource	function	Resources
LoadScrap	function	Scrap
LocalToGlobal	function	Quickdraw
log	function	exp(C)
log1	function	SANE
log10	function	exp(C)
log2	function	SANE
logb	function	SANE
london	define	Fonts
long	type	Types
Long2Fix	function	FixMath
longDate	literal	Packages
longjmp	function	setjmp(C)
LongMul	function	ToolUtils
lOnlyOne	define	Lists
LookAt	function	Graf3D
losAngeles	define	Fonts
LoWord	function	ToolUtils
lPaintBits	define	Printing
lPrLFSixth	define	Printing
lPrLineFeed	define	Printing
lPrPageEnd	define	Printing
lPrReset	define	Printing
LRect	function	Lists
lScreenBits	define	Printing
LScroll	function	Lists
LSearch	function	Lists
lseek	function	lseek(C)
LSetCell	function	Lists
LSetSelect	function	Lists
LSize	function	Lists
LUpdate	function	Lists
lUseSense	define	Lists
macMachine	define	OSUtils
MacOSErr	short	errorintro(C)
macXLMachine	define	OSUtils
magentaBit	define	Quickdraw
magentaColor	define	Quickdraw
malloc	function	malloc(C)
mapChanged	define	Resources
mapCompact	define	Resources
MapPoly	function	Quickdraw
MapPt	function	Quickdraw
mapReadErr	define	Errors
mapReadOnly	define	Resources
MapRect	function	Quickdraw
MapRgn	function	Quickdraw
MaxApplZone	function	Memory

Identifier	Type	Manual page
MaxBlock	function	Memory
MaxMem	function	Memory
maxSize	define	Memory
MaxSizeRsrc	function	Resources
mChooseMsg	define	Menus
mDownMask	define	Events
mDrawMsg	define	Menus
mdy	define	Packages
MeasureText	function	Quickdraw
memAdrErr	define	Errors
memAZErr	define	Errors
memBCErr	define	Errors
memccpy	function	Memory (C)
memchr	function	Memory (C)
memcmp	function	Memory (C)
memcpy	function	Memory (C)
MemError	function	Memory
memFullErr	define	Errors
memLockedErr	define	Errors
memPCErr	define	Errors
memPurErr	define	Errors
memROZErr	define	Errors
memSCErr	define	Errors
memset	function	Memory (C)
memWZErr	define	Errors
MenuHandle	type	Menus
MenuInfo	type	Menus
MenuKey	function	Menus
menuPrgErr	define	Errors
MenuPtr	type	Menus
MenuSelect	function	Menus
minLeadingZ	define	Packages
mntLdingZ	define	Packages
mobile	define	Fonts

Identifier	Type	Manual page
ModalDialog	function	Dialogs
modf	function	frexp(C)
monaco	define	Fonts
MoreMasters	function	Memory
mouseDown	define	Events
mouseUp	define	Events
Move	function	Quickdraw
Move2D	function	Graf3D
Move3D	function	Graf3D
MoveControl	function	Controls
MoveHHi	function	Memory
MovePortTo	function	Quickdraw
MoveTo	function	Quickdraw
MoveTo2D	function	Graf3D
MoveTo3D	function	Graf3D
MoveWindow	function	Windows
MPPClose	function	AppleTalk
MPPOpen	function	AppleTalk
mSizeMsg	define	Menus
Munger	function	ToolUtils
mUpMask	define	Events
MyAction	function	Controls
MyAction	function	Windows
MyArc	function	Quickdraw
MyBits	function	Quickdraw
MyClikLoop	function	TextEdit
MyComment	function	Quickdraw
MyControl	function	Controls
MyDlg	function	Packages
MyFileFilter	function	Packages
MyFilter	function	Dialogs
MyGetPic	function	Quickdraw
MyGrowZone	function	Memory
MyItem	function	Dialogs

Identifier	Type	Manual page
MyLine	function	Quickdraw
MyListDef	function	Lists
MyMenu	function	Menus
MyOval	function	Quickdraw
MyPoly	function	Quickdraw
MyPutPic	function	Quickdraw
MyRect	function	Quickdraw
MyRgn	function	Quickdraw
MyRRect	function	Quickdraw
MySound	function	Dialogs
MyText	function	Quickdraw
MyTxMeas	function	Quickdraw
MyWindow	function	Windows
MyWordBreak	function	TextEdit
nan	function	SANE
nbpBuffOvr	define	AppleTalk
nbpConfDiff	define	AppleTalk
NBPConfirm	function	AppleTalk
nbpDuplicate	define	AppleTalk
NBPExtract	function	AppleTalk
NBPLoad	function	AppleTalk
NBPLookUp	function	AppleTalk
nbpNISErr	define	Errors
nbpNoConfirm	define	AppleTalk
nbpNotFound	define	AppleTalk
nbpProto	literal	AppleTalk
NBPRegister	function	AppleTalk
NBPRemove	function	AppleTalk
nbpSize	define	AppleTalk
NBPUnLoad	function	AppleTalk
networkEvt	define	Events
networkMask	define	Events
NewControl	function	Controls
NewDialog	function	Dialogs

Identifier	Type	Manual page
NewEmptyHandle	function	Memory
NewHandle	function	Memory
NewMenu	function	Menus
NewPtr	function	Memory
NewRgn	function	Quickdraw
newSelMsg	define	Devices
NewString	function	ToolUtils
NewWindow	function	Windows
newYork	define	Fonts
nextdouble	function	SANE
nextextended	function	SANE
nextfloat	function	SANE
NGetTrapAddress	function	OSUtils
nil	define	Types
nilHandleErr	define	Errors
noAdrMkErr	define	Errors
noBridgeErr	define	Errors
noConstraint	define	Controls
noConstraint	define	Windows
noDataArea	define	AppleTalk
noDriveErr	define	Errors
noDtaMkErr	define	Errors
noErr	define	Errors
noGrowDocProc	define	Windows
noMacDskErr	define	Errors
noMark	define	Menus
noMPPErr	define	Errors
noNybErr	define	Errors
noParity	define	Serial
noRelErr	define	Errors
normal	define	Quickdraw
normalBit	define	Quickdraw
NORMALNUM	define	SANE
noScrapErr	define	Errors

Identifier	Type	Manual page
noSendResp	define	AppleTalk
NoteAlert	function	Dialogs
noteIcon	define	Dialogs
notOpenErr	define	Errors
notPatBic	define	Quickdraw
notPatCopy	define	Quickdraw
notPatOr	define	Quickdraw
notPatXor	define	Quickdraw
notSrcBic	define	Quickdraw
notSrcCopy	define	Quickdraw
notSrcOr	define	Quickdraw
notSrcXor	define	Quickdraw
noTypeErr	define	Errors
nsDrvErr	define	Errors
NSetTrapAddress	function	OSUtils
nsvErr	define	Errors
NULL	define	stdio(C)
NULL	define	Types
nullEvent	define	Events
num2dec	function	SANE
numclass	type	SANE
NumToString	function	Packages
O_APPEND	define	open(C)
ObscureCursor	function	Quickdraw
O_CREAT	define	open(C)
oddParity	define	Serial
O_EXCL	define	open(C)
offLinErr	define	Errors
OffsetPoly	function	Quickdraw
OffsetRect	function	Quickdraw
OffsetRgn	function	Quickdraw
okButton	define	Dialogs
onexit	function	onexit(C)
open	function	open(C)

Identifier	Type	Manual page
Open3DPort	function	Graf3D
OpenDeskAcc	function	Desk
OpenDriver	function	Devices
openErr	define	Errors
OpenFRPerm	function	Resources
OpenPicture	function	Quickdraw
OpenPoly	function	Quickdraw
OpenPort	function	Quickdraw
OpenResFile	function	Resources
OpenRF	function	Files
openRFPerm	function	Resources
OpenRgn	function	Quickdraw
optionKey	define	Events
opWrErr	define	Errors
O_RDONLY	define	open(C)
O_RDWR	define	open(C)
O_RSRC	define	open(C)
OSErr	type	Types
OSEventAvail	function	OSEvents
OSTrap	literal	OSUtils
OSType	type	Types
O_TRUNC	define	open(C)
outline	define	Quickdraw
OVERFLOW	define	SANE
O_WRONLY	define	open(C)
p2cstr	function	Strings
PackBits	function	ToolUtils
paint	literal	Quickdraw
PaintArc	function	Quickdraw
PaintBehind	function	Windows
PaintOne	function	Windows
PaintOval	function	Quickdraw
PaintPoly	function	Quickdraw
PaintRect	function	Quickdraw

Identifier	Type	Manual page
PaintRgn	function	Quickdraw
PaintRoundRect	function	Quickdraw
paramErr	define	Errors
ParamText	function	Dialogs
parityErr	define	Errors
patBic	define	Quickdraw
patCopy	define	Quickdraw
PatHandle	type	ToolUtils
patOr	define	Quickdraw
PatPtr	type	ToolUtils
Pattern	type	Quickdraw
patXor	define	Quickdraw
PBAllocate	function	Files
PBAllocContig	function	Files
PBCatMove	function	Files
PBClose	function	Files
PBCloseWD	function	Files
PBControl	function	Devices
PBCreate	function	Files
PBDelete	function	Files
PBDirCreate	function	Files
PBEject	function	Files
PBFlushFile	function	Files
PBFlushVol	function	Files
PBGetCatInfo	function	Files
PBGetEOF	function	Files
PBGetFCBInfo	function	Files
PBGetFInfo	function	Files
PBGetFPos	function	Files
PBGetVInfo	function	Files
PBGetVol	function	Files
PBGetWDInfo	function	Files
PBHCreate	function	Files
PBHDelete	function	Files

Identifier	Type	Manual page
PBHGetFInfo	function	Files
PBHGetVInfo	function	Files
PBHGetVol	function	Files
PBHOpen	function	Files
PBHOpenRF	function	Files
PBHRename	function	Files
PBHRstFLock	function	Files
PBHSetFInfo	function	Files
PBHSetFLock	function	Files
PBHSetVol	function	Files
PBKillIO	function	Devices
PBLockRange	function	Files
PBMountVol	function	Files
PBOffLine	function	Files
PBOpen	function	Files
PBOpenRF	function	Files
PBOpenWD	function	Files
PBRead	function	Files
PBRename	function	Files
PBRstFLock	function	Files
PBSetCatInfo	function	Files
PBSetEOF	function	Files
PBSetFInfo	function	Files
PBSetFLock	function	Files
PBSetFPos	function	Files
PBSetFVers	function	Files
PBSetVInfo	function	Files
PBSetVol	function	Files
PBStatus	function	Devices
PBUnLockRange	function	Files
PBUnmountVol	function	Files
PBWrite	function	Files
PDSIGWORD	define	SCSI
PenMode	function	Quickdraw

Identifier	Type	Manual page
PenNormal	function	Quickdraw
PenPat	function	Quickdraw
PenSize	function	Quickdraw
PenState	type	Quickdraw
permErr	define	Errors
pi	function	SANE
PicComment	function	Quickdraw
PicHandle	type	Quickdraw
picItem	define	Dialogs
picLParen	define	Quickdraw
PicPtr	type	Quickdraw
picRParen	define	Quickdraw
Picture	type	Quickdraw
PinRect	function	Windows
Pitch	function	Graf3D
plainDBox	define	Windows
PlotIcon	function	ToolUtils
plusCursor	define	ToolUtils
Point	type	Types
Point2D	type	Graf3D
Point3D	type	Graf3D
Polygon	type	Quickdraw
PolyHandle	type	Quickdraw
PolyPtr	type	Quickdraw
Port3D	type	Graf3D
Port3DPtr	type	Graf3D
portInUse	define	Errors
portNotCf	define	Errors
PortSize	function	Quickdraw
posCntl	define	Controls
posErr	define	Errors
PostEvent	function	OSEvents
pow	function	exp(C)
power	function	SANE

Identifier	Type	Manual page
PPostEvent	function	OSEvents
PrClose	function	Printing
PrCloseDoc	function	Printing
PrClosePage	function	Printing
PrCtlCall	function	Printing
PrDrvrClose	function	Printing
PrDrvrDCE	function	Printing
PrDrvrOpen	function	Printing
PrDrvrVers	function	Printing
PrError	function	Printing
PrimeTime	function	Time
prInitErr	define	Errors
PrintDefault	function	Printing
printf	function	printf(C)
PrJobDialog	function	Printing
PrJobMerge	function	Printing
procentry	function	SANE
procexit	function	SANE
ProcHandle	type	Types
ProcPtr	type	Types
PrOpen	function	Printing
PrOpenDoc	function	Printing
PrOpenPage	function	Printing
propFont	define	Fonts
prpFntH	define	Fonts
prpFntHW	define	Fonts
prpFntW	define	Fonts
PrPicFile	function	Printing
PrSetError	function	Printing
PrStlDialog	function	Printing
PrValidate	function	Printing
prWrErr	define	Errors
PScrapStuff	type	Scrap
Pt2Rect	function	Quickdraw

Identifier	Type	Manual page
PtInRect	function	Quickdraw
PtInRgn	function	Quickdraw
Ptr	type	Types
PtrAndHand	function	OSUtils
PtrToHand	function	OSUtils
PtrToXHand	function	OSUtils
PtrZone	function	Memory
PtToAngle	function	Quickdraw
PurgeMem	function	Memory
PurgeSpace	function	Memory
pushButProc	define	Controls
putc	macro	putc(C)
putCancel	define	Packages
putchar	macro	putc(C)
putDlgID	define	Packages
putDrive	define	Packages
putEject	define	Packages
putName	define	Packages
puts	function	puts(C)
putSave	define	Packages
PutScrap	function	Scrap
putw	function	putc(C)
QDProcs	type	Quickdraw
QDProcsPtr	type	Quickdraw
QElem	type	OSUtils
QElemPtr	type	OSUtils
qErr	define	Errors
QHdr	type	OSUtils
QHdrPtr	type	OSUtils
QNAN	define	SANE
qsort	function	qsort(C)
QTypes	type	OSUtils
radConst	define	Graf3D
radCtrl	define	Dialogs

Identifier	Type	Manual page
radioButProc	define	Controls
RAMSDClose	function	Serial
RAMSDOpen	function	Serial
rand	function	rand(C)
Random	function	Quickdraw
randomx	function	SANE
rcvrErr	define	Errors
rDocProc	define	Windows
rdVerify	define	disks
rdVerify	define	Files
read	function	read(C)
ReadDateTime	function	OSUtils
readErr	define	Errors
readQErr	define	Errors
realloc	function	malloc(C)
ReallocHandle	function	Memory
recNotFnd	define	AppleTalk
RecoverHandle	function	Memory
Rect	type	Types
RectInRgn	function	Quickdraw
RectRgn	function	Quickdraw
redBit	define	Quickdraw
redColor	define	Quickdraw
Region	type	Quickdraw
relation	function	SANE
ReleaseResource	function	Resources
relop	type	SANE
RelString	function	OSUtils
remainder	function	SANE
RemoveHdlBlks	function	AppleTalk
Rename	function	Files
reqAborted	define	AppleTalk
reqFailed	define	AppleTalk
resAttrErr	define	Errors

Identifier	Type	Manual page
resChanged	define	Resources
resCtrl	define	Dialogs
ResError	function	Resources
ResetAlrtStage	function	Dialogs
resFNotFound	define	Errors
resLocked	define	Resources
resNotFound	define	Errors
resPreload	define	Resources
resProtected	define	Resources
resPurgeable	define	Resources
ResrvMem	function	Memory
resSysHeap	define	Resources
Restart	function	OSUtils
ResType	type	Types
RetransType	type	AppleTalk
rewind	function	fseek(C)
rfNumErr	define	Errors
RgnHandle	type	Quickdraw
RgnPtr	type	Quickdraw
rindex	function	string(C)
rint	function	SANE
RmveResource	function	Resources
rmvRefFailed	define	Errors
rmvResFailed	define	Errors
RmvTime	function	Time
Roll	function	Graf3D
rounddir	type	SANE
roundpre	type	SANE
RsrcMapEntry	function	Resources
RsrcZoneInit	function	Resources
RstFLock	function	Files
sanFran	define	Fonts
SaveOld	function	Windows
SBSIGWORD	define	SCSI

Identifier	Type	Manual page
scAdd	define	SCSI
scalb	function	SANE
Scale	function	Graf3D
ScalePt	function	Quickdraw
scanBT	literal	Printing
scanf	function	scanf(C)
scanLR	literal	Printing
scanRL	literal	Printing
scanTB	literal	Printing
scBadParmsErr	define	Errors
scCommErr	define	Errors
scComp	define	SCSI
scCompareErr	define	Errors
scInc	define	SCSI
scLoop	define	SCSI
scMove	define	SCSI
scNoInc	define	SCSI
scNop	define	SCSI
scPhaseErr	define	Errors
ScrapStuff	type	Scrap
ScreenRes	function	ToolUtils
scrollBarProc	define	Controls
ScrollRect	function	Quickdraw
SCSICmd	function	SCSI
SCSIComplete	function	SCSI
SCSIGet	function	SCSI
SCSIRBlind	function	SCSI
SCSIRead	function	SCSI
SCSIReset	function	SCSI
SCSISelect	function	SCSI
SCSIStat	function	SCSI
SCSIWBlind	function	SCSI
SCSIWrite	function	SCSI
scStop	define	SCSI

Identifier	Type	Manual page
secLeadingZ	define	Packages
Secs2Date	function	OSUtils
sectNFErr	define	Errors
SectRect	function	Quickdraw
SectRgn	function	Quickdraw
SeedFill	function	Quickdraw
seekErr	define	Errors
select	define	Desk
selectMsg	define	Devices
SelectWindow	function	Windows
SelIText	function	Dialogs
SendBehind	function	Windows
SENoDB	define	Errors
SerClrBrk	function	Serial
SerGetBuf	function	Serial
SerHShake	function	Serial
SerReset	function	Serial
SerSetBrk	function	Serial
SerSetBuf	function	Serial
SerShk	type	Serial
SerStaRec	type	Serial
SerStatus	function	Serial
SetApplBase	function	Memory
SetApplLimit	function	Memory
setbuf	function	setbuf(C)
SetClikLoop	function	TextEdit
SetClip	function	Quickdraw
SetCRefCon	function	Controls
SetCTitle	function	Controls
SetCtlAction	function	Controls
SetCtlMax	function	Controls
SetCtlMin	function	Controls
SetCtlValue	function	Controls
SetCursor	function	Quickdraw

Identifier	Type	Manual page
SetDAFont	function	Dialogs
SetDateTime	function	OSUtils
SetDItem	function	Dialogs
SetEmptyRgn	function	Quickdraw
setenvironment	function	SANE
SetEOF	function	Files
SetEventMask	function	OSEvents
setexception	function	SANE
SetFInfo	function	Files
SetFLock	function	Files
SetFPos	function	Files
SetGrowZone	function	Memory
sethalt	function	SANE
sethaltvector	function	SANE
SetHandleSize	function	Memory
SetItem	function	Menus
SetItemIcon	function	Menus
SetItemMark	function	Menus
SetItemStyle	function	Menus
SetIText	function	Dialogs
setjmp	function	setjmp(C)
SetMenuBar	function	Menus
SetMenuFlash	function	Menus
SetOrigin	function	Quickdraw
SetPenState	function	Quickdraw
SetPort	function	Quickdraw
SetPort3D	function	Graf3D
SetPortBits	function	Quickdraw
setprecision	function	SANE
SetPt	function	Quickdraw
SetPt2D	function	Graf3D
SetPt3D	function	Graf3D
SetPtrSize	function	Memory
SetRect	function	Quickdraw

Identifier	Type	Manual page
SetRectRgn	function	Quickdraw
SetResAttrs	function	Resources
SetResFileAttrs	function	Resources
SetResInfo	function	Resources
SetResLoad	function	Resources
SetResPurge	function	Resources
setround	function	SANE
SetStdProcs	function	Quickdraw
SetString	function	ToolUtils
SetTagBuffer	function	disks
SetTime	function	OSUtils
SetTrapAddress	function	OSUtils
setvbuf	function	setbuf(C)
SetVol	function	Files
SetWindowPic	function	Windows
SetWordBreak	function	TextEdit
SetWRefCon	function	Windows
SetWTitle	function	Windows
SetZone	function	Memory
SFGetFile	function	Packages
SFPGetFile	function	Packages
SFPPutFile	function	Packages
SFPutFile	function	Packages
SFReply	type	Packages
SFTypeList	type	Packages
shadow	define	Quickdraw
ShieldCursor	function	ToolUtils
shiftKey	define	Events
shortDate	literal	Packages
ShowControl	function	Controls
ShowCursor	function	Quickdraw
ShowDItem	function	Dialogs
ShowHide	function	Windows
ShowPen	function	Quickdraw

Identifier	Type	Manual page
ShowWindow	function	Windows
SIGALLSIGS	define	signal(C)
SIG_DFL	define	signal(C)
_sig_dfl	function	signal(C)
SIGDIGLEN	define	SANE
sighold	function	signal(C)
SIG_IGN	define	signal(C)
SIGINT	define	signal(C)
SignalHandler	type	signal(C)
SignalMap	type	signal(C)
signnum	function	SANE
sigpause	function	signal(C)
sigrelease	function	signal(C)
sigset	function	signal(C)
sin	function	trig(C)
sinh	function	sinh(C)
Size	type	Memory
SizeControl	function	Controls
SizeResource	function	Resources
SizeWindow	function	Windows
Skew	function	Graf3D
sktClosedErr	define	Errors
SlopeFromAngle	function	ToolUtils
SNAN	define	SANE
sony	literal	disks
SpaceExtra	function	Quickdraw
spdAdjErr	define	Errors
sPortA	literal	Serial
sPortB	literal	Serial
SPortSel	type	Serial
sPrDrvr	define	Printing
sprintf	function	printf(C)
sqrt	function	exp(C)
srand	function	rand(C)

Identifier	Type	Manual page	Identifier	Type	Manual page
srcBic	define	Quickdraw	str2dec	function	SANE
srcCopy	define	Quickdraw	strcat	function	string(C)
srcOr	define	Quickdraw	strchr	function	string(C)
srcXor	define	Quickdraw	strcmp	function	string(C)
sscanf	function	scanf(C)	strcpy	function	string(C)
StackSpace	function	Memory	strcspn	function	string(C)
StageList	type	Dialogs	String	define	Types
statText	define	Dialogs	StringHandle	type	Types
Status	function	Devices	StringPtr	type	Types
statusErr	define	Errors	StringToNum	function	Packages
StdArc	function	Quickdraw	StringWidth	function	Quickdraw
StdBits	function	Quickdraw	strlen	function	string(C)
StdComment	function	Quickdraw	strncat	function	string(C)
stderr	define	stdio(C)	strncmp	function	string(C)
stdFile	define	Packages	strncpy	function	string(C)
StdGetPic	function	Quickdraw	strpbrk	function	string(C)
stdin	define	stdio(C)	strrchr	function	string(C)
StdLine	function	Quickdraw	strspn	function	string(C)
stdout	define	stdio(C)	strtok	function	string(C)
StdOval	function	Quickdraw	strtol	function	strtol(C)
StdPoly	function	Quickdraw	StuffHex	function	Quickdraw
StdPutPic	function	Quickdraw	Style	type	Types
StdRect	function	Quickdraw	SubPt	function	Quickdraw
StdRgn	function	Quickdraw	swMode	define	Sound
StdRRect	function	Quickdraw	swOverrunErr	define	Errors
StdText	function	Quickdraw	symbol	define	Fonts
StdTxMeas	function	Quickdraw	SysBeep	function	OSUtils
StillDown	function	Events	SysError	function	Errors
stop10	define	Serial	SysParmType	type	OSUtils
stop15	define	Serial	sysPatListID	define	ToolUtils
stop20	define	Serial	SysPPtr	type	OSUtils
StopAlert	function	Dialogs	SystemClick	function	Desk
stopIcon	define	Dialogs	SystemEdit	function	Desk
Str255	type	Types	SystemEvent	function	Desk

Identifier	Type	Manual page
systemFont	define	Fonts
SystemMenu	function	Desk
SystemTask	function	Desk
SystemZone	function	Memory
tan	function	trig(C)
tanh	function	sinh(C)
tATPAddRsp	literal	AppleTalk
tATPGetRequest	literal	AppleTalk
tATPRequest	literal	AppleTalk
tATPResponse	literal	AppleTalk
tATPSdRsp	literal	AppleTalk
tATPSndRequest	literal	AppleTalk
tDDPRead	literal	AppleTalk
tDDPWrite	literal	AppleTalk
TEActivate	function	TextEdit
TEAutoView	function	TextEdit
TECalText	function	TextEdit
TEClick	function	TextEdit
TECopy	function	TextEdit
TECut	function	TextEdit
TEDeactivate	function	TextEdit
TEDelete	function	TextEdit
TEDispose	function	TextEdit
TEFromScrap	function	TextEdit
TEGetScrapLen	function	TextEdit
TEGetText	function	TextEdit
TEHandle	type	TextEdit
TEIdle	function	TextEdit
TEInit	function	TextEdit
TEInsert	function	TextEdit
teJustCenter	define	TextEdit
teJustLeft	define	TextEdit
teJustRight	define	TextEdit
TEKey	function	TextEdit

Identifier	Type	Manual page
TENew	function	TextEdit
TEPaste	function	TextEdit
TEPinScroll	function	TextEdit
TEPtr	type	TextEdit
TERec	type	TextEdit
terminate	define	Desk
terminateMsg	define	Devices
TEScrapHandle	function	TextEdit
TEScroll	function	TextEdit
TESelView	function	TextEdit
TESetJust	function	TextEdit
TESetScrapLen	function	TextEdit
TESetSelect	function	TextEdit
TESetText	function	TextEdit
testCntl	define	Controls
TestControl	function	Controls
testexception	function	SANE
testhalt	function	SANE
TESysJust	define	Menus
TEToScrap	function	TextEdit
TEUpdate	function	TextEdit
TextBox	function	TextEdit
TextFace	function	Quickdraw
TextFont	function	Quickdraw
textMenuProc	define	Menus
TextMode	function	Quickdraw
TextSize	function	Quickdraw
TextWidth	function	Quickdraw
TFeed	type	Printing
TFSID	define	SCSI
THPrint	type	Printing
thumbCntl	define	Controls
THz	type	Memory
TickCount	function	Events

Identifier	Type	Manual page
times	define	Fonts
TIOFLUSH	define	ioctl(C)
TIOGPORT	define	ioctl(C)
TIOSPORT	define	ioctl(C)
tk0BadErr	define	Errors
tLAPRead	literal	AppleTalk
tLAPWrite	literal	AppleTalk
tmfoErr	define	Errors
TMTask	type	Time
tmwdoErr	define	Errors
tNBPConfirm	literal	AppleTalk
tNBPLookUp	literal	AppleTalk
tNBPRegister	literal	AppleTalk
toascii	macro	conv(C)
tolower	function	conv(C)
_tolower	macro	conv(C)
TONEAREST	define	SANE
ToolTrap	literal	OSUtils
tooManyReqs	define	AppleTalk
tooManySkts	define	AppleTalk
TopMem	function	Memory
toronto	define	Fonts
toupper	function	conv(C)
_toupper	macro	conv(C)
TOWARDZERO	define	SANE
TPPrint	type	Printing
TPPrPort	type	Printing
TPRect	type	Printing
TPrInfo	type	Printing
TPrint	type	Printing
TPrJob	type	Printing
TPrPort	type	Printing
TPrStatus	type	Printing
TPrStl	type	Printing

Identifier	Type	Manual page
TPrXInfo	type	Printing
TrackBox	function	Windows
TrackControl	function	Controls
TrackGoAway	function	Windows
Transform	function	Graf3D
Translate	function	Graf3D
TrapType	type	OSUtils
trFunct	define	Packages
true	literal	Types
TScan	type	Printing
twoSideErr	define	Errors
UNDERFLOW	define	SANE
underline	define	Quickdraw
ungetc	function	ungetc(C)
unimpErr	define	Errors
UnionRect	function	Quickdraw
UnionRgn	function	Quickdraw
Unique1ID	function	Resources
UniqueID	function	Resources
unitEmptyErr	define	Errors
unlink	function	unlink(C)
UnloadScrap	function	Scrap
UnloadSeg	function	SegLoad
UnmountVol	function	Files
UNORDERED	define	SANE
UnpackBits	function	ToolUtils
updateEvt	define	Events
updateMask	define	Events
UpdateResFile	function	Resources
UpdtControl	function	Controls
UpdtDialog	function	Dialogs
UprString	function	OSUtils
UPWARD	define	SANE
useAsync	define	OSUtils

Identifier	Type	Manual page
useATalk	define	OSUtils
useFree	define	OSUtils
UseResFile	function	Resources
userItem	define	Dialogs
userKind	define	Windows
useWFont	define	Controls
ValidRect	function	Windows
ValidRgn	function	Windows
vAxisOnly	define	Controls
vAxisOnly	define	Windows
VBLTask	type	Retrace
VCB	type	Files
venice	define	Fonts
verArabia	define	Packages
verAustralia	define	Packages
verBelgiumLux	define	Packages
verBritain	define	Packages
verCyprus	define	Packages
verDenmark	define	Packages
verFinland	define	Packages
verFrance	define	Packages
verFrCanada	define	Packages
verFrSwiss	define	Packages
verGermany	define	Packages
verGreece	define	Packages
verGrSwiss	define	Packages
verIceland	define	Packages
verIsrael	define	Packages
verItaly	define	Packages
verJapan	define	Packages
verMalta	define	Packages
verNetherlands	define	Packages
verNorway	define	Packages
verPortugal	define	Packages

Identifier	Type	Manual page
verSpain	define	Packages
verSweden	define	Packages
verTurkey	define	Packages
verUS	define	Packages
verYugoslavia	define	Packages
ViewAngle	function	Graf3D
ViewPort	function	Graf3D
VInstall	function	Retrace
vLckdErr	define	Errors
volOffLinErr	define	Errors
volOnLinErr	define	Errors
VolumeParam	type	Files
VRemove	function	Retrace
vType	literal	OSUtils
vTypErr	define	Errors
WaitMouseUp	function	Events
watchCursor	define	ToolUtils
Wave	type	Sound
wCalcRgns	define	Windows
wDispose	define	Windows
WDPBRec	type	Files
wDraw	define	Windows
wDrawGIcon	define	Windows
wGrow	define	Windows
wHit	define	Windows
whiteColor	define	Quickdraw
WidthTable	type	Fonts
wInContent	define	Windows
WindowPeek	type	Windows
WindowPtr	type	Windows
WindowRecord	type	Windows
wInDrag	define	Windows
wInGoAway	define	Windows
wInGrow	define	Windows

Identifier	Type	Manual page	Identifier	Type	Manual page
wInZoomIn	define	Windows			
WInZoomOut	define	Windows			
wNew	define	Windows			
wNoHit	define	Windows			
wPrErr	define	Errors			
wrgVolTypErr	define	Errors			
write	function	write(C)			
WriteParam	function	OSUtils			
WriteResource	function	Resources			
writErr	define	Errors			
wrPermErr	define	Errors			
wrUnderrun	define	Errors			
WStateData	type	Windows			
X2Fix	function	FixMath			
X2Frac	function	FixMath			
XfMatrix	type	Graf3D			
xOffWasSent	define	Serial			
XorRgn	function	Quickdraw			
Yaw	function	Graf3D			
yellowBit	define	Quickdraw			
yellowColor	define	Quickdraw			
ymd	define	Packages			
ZERONUM	define	SANE			
ZeroScrap	function	Scrap			
Zone	type	Memory			
ZoomWindow	function	Windows			

Appendix D

Graf3D: Three-Dimensional Graphics

Graf3D is a C library that uses QuickDraw calls to produce three-dimensional graphics. It does this by providing a fixed-point interface to QuickDraw's integer coordinates.

The Graf3D routines provide several important features:

- A camera's-eye view. This allows you to set the point of view from which the observer sees the object independently from the coordinates of the object itself. The camera is set up with the `ViewPort`, `LookAt`, and `ViewAngle` functions. You can set the focal length of the camera as if you had a choice of telephoto, wide-angle, or normal lenses.
- Three-dimensional clipping to a true pyramid. The apex of the pyramid is at the point of the camera eye, and the base of the pyramid is equivalent to the `ViewPort`. When you use the `Clip3D` function, only objects in front of the camera eye and within the pyramid are displayed on the screen.
- Two-dimensional point and line capability using fixed-point coordinates. Graf3D provides commands corresponding to the QuickDraw commands but using fixed-point coordinates instead of integers. With fixed-point coordinates you have a larger dynamic range for graphics calculations; with integer coordinates you get faster drawing time.
- Two-dimensional or three-dimensional rotation. You can rotate an object along any or all axes simultaneously, using the `Pitch`, `Yaw`, and `Roll` functions.
- Translation and scaling of objects in one or more axes simultaneously. *Translation* means movement anywhere in three-dimensional space. *Scaling* means shrinking or expanding.

How to use Graf3D

To use Graf3D, do the following:

1. Include the statements

   ```
   #include     <Types.h>
   #include     <QuickDraw.h>
   #include     <Graf3D.h>
   ```

   in your source text.
2. Link your object file with the file {Libraries} Interface.o.
3. Set values in the Graf3D data structures and call the Graf3D routines from your program, following the information given below.

Graf3D data types

Graf3D declares and uses these data types:

- `Fixed`
- `Point3D`
- `Point2D`
- `XfMatrix`
- `Port3DPtr`

These types are discussed below.

Point3D

```
typedef struct Point3D {
   Fixed       x, y, z;
} Point3D;
```

`Point3D` contains three fixed-point coordinates: x, y, and z. Graf3D uses x, y, and z for fixed-point coordinates to distinguish between the *h* and *v* integer screen coordinates used by QuickDraw.

Point2D

```
typedef struct Point2D {
   Fixed       x, y;
} Point2D;
```

Point2D is just like a Point3D but contains only x and y coordinates.

XfMatrix

```
typedef Fixed XfMatrix[4][4];
```

The XfMatrix is a 4x4 matrix of Fixed values, used to hold a transformation equation. Each transforming routine alters this matrix so that it contains the concatenated effects of all transformations applied.

Port3D, Port3DPtr

```
typedef struct Port3D {
   GrafPtr  grPort;
   Rect     viewRect;
   Fixed    xLeft, yTop, xRight, yBottom;
   Point3D  pen, penPrime, eye;
   Fixed    hSize, vSize;
   Fixed    hCenter, vCenter;
   Fixed    xCotan, yCotan;
   char     filler;
   char     ident;
   Fixed    xForm[4][4];
} Port3D, *Port3DPtr;
```

The type Port3DPtr contains all the state variables needed to map fixed-point coordinates into integer screen coordinates. These are the variables:

Name	Description
GrPort	Pointer to the grafPort associated with this Port3D
viewRect	Viewing rectangle within the grafPort; the base of the viewing pyramid
xLeft, yTop, xRight, yBottom	World coordinates corresponding to the viewRect
pen	Three-dimensional pen location
penPrime	Pen location transformed by the xForm matrix
eye	Three-dimensional viewpoint location established by ViewAngle
hSize, vSize	Half-width and half-height of the viewRect in screen coordinates
hCenter, vCenter	Center of the viewRect in screen coordinates
xCotan, yCotan	Viewing cotangents set up by ViewAngle, used by Clip3D

`ident`	`Boolean` variable (stored as a `char`) that allows the transformation to be skipped when `xForm` is an identity matrix
`filler`	`Char` filler field to match Pascal format
`xForm`	4x4 matrix that holds the net result of all transformations

Graphics functions

Graf3D provides several functions to establish a graphics environment and create drawings within it. They are described in this section.

The InitGraf3D function

```
pascal void InitGrf3D(port)
   Port3DPtr *port;
```

The `InitGraf3D` function initializes the `Port3D` variable. Call this routine before doing Graf3D operations. You must allocate space for a variable of type Port3DPtr (whose address is passed as a parameter to this function).

The Open3DPort function

```
pascal void Open3DPort(port)
   Port3DPtr port;
```

The `Open3DPort` function initializes all the fields of a `Port3D` to their defaults, and makes that `Port3D` the current one. `Grport` is set to the currently open `grafPort`. These are the default values:

```
Open3DPort  Function  p. D-19
   thePort3D = port;
   port->grPort = qd.thePort;
   ViewPort(qd.thePort->portRect);
   LookAt(qd.thePort->portRect.left, qd.thePort->portRect.top,
       qd.thePort->portRect.right, qd.thePort->portRect.bottom);
   ViewAngle(X2Fix(0.0));
   Identity;
   MoveTo3D(X2Fix(0.0),X2Fix(0.0),X2Fix(0.0));
```

The SetPort3D function

```
pascal void SetPort3D(port)
```

```
    Port3DPtr  port;
```

The `SetPort3D` function makes `port` the current `Port3D` and calls `SetPort` for that `Port3D`'s associated `grafPort`. `SetPort3D` allows an application to use more than one `Port3D` and switch between them.

The GetPort3D function

```
pascal void GetPort3D(port)
   Port3D   *port;
```

The `GetPort3D` function returns a pointer to the current `Port3D`. This function is useful when you are using several `Port3D`s and want to save and restore the current one.

The Move functions

Graf3D provides four Move functions:

```
pascal void MoveTo2D(x, y)
   Fixed     x, y;
pascal void MoveTo3D(x, y, z)
   Fixed     x, y, z;
pascal void Move2D(x, y)
   Fixed     x, y;
pascal void Move3D(x, y, z)
   Fixed     x, y, z;
```

These functions move the pen in two or three dimensions without drawing lines. The fixed-point coordinates are transformed by the `xForm` matrix and projected onto flat screen coordinates; then Graf3D calls QuickDraw's `MoveTo` function with the result.

The Line functions

Graf3D provides four Line functions:

```
pascal void LineTo2D(x, y)
   Fixed     x, y;
pascal void LineTo3D(x, y, z)
   Fixed     x, y, z;
pascal void Line2D(x, y)
   Fixed     x, y;
pascal void Line3D(x, y, z)
   Fixed     x, y, z;
```

These functions draw two- and three-dimensional lines from the current pen location. The LineTo2D and LineTo3D functions stay on the same *z*-plane. The fixed-point coordinates are first transformed by the xForm matrix, then clipped to the viewing pyramid, then projected onto the flat screen coordinates and drawn by calling QuickDraw's LineTo function.

The Clip3D function

```
pascal short Clip3D(src1, src2, dst1, dst2)
   Point3D    *src1, *src2;
   Point      *dst1, *dst2;
```

The Clip3D function clips a three-dimensional line segment to the viewing pyramid and returns the clipped line projected onto screen coordinates. Clip3D returns true (nonzero) if any part of the line is visible. If no part of the line is within the viewing pyramid, Clip3D returns false (zero).

The Set Point functions

```
pascal void SetPt3D(pt3D, x, y, z)
   Point3D  *pt3D;
   Fixed    x, y, z;
pascal void SetPt2D(pt2D, x, y)
   Point2D  *pt2D;
   Fixed    x, y;
```

The SetPt3D function assigns three fixed-point values to a Point3D. The SetPtr2D function assigns two fixed-point values to a Point2D.

Setting up the camera

Functions ViewPort, LookAt, and ViewAngle position the image in the grafPort, aim the camera, and choose the lens focal length in order to map three-dimensional coordinates onto the flat screen space. These functions may be called in any order.

The ViewPort function

```
pascal void ViewPort(r)
   Rect      *r;
```

The `ViewPort` function specifies where to put the image in the `grafPort`. The `ViewPort` rectangle is in integer QuickDraw coordinates, and tells where to map the `LookAt` coordinates.

The LookAt function

```
pascal void LookAt(left, top, right, bottom)
   Fixed    left, top, right, bottom;
```

The `LookAt` function specifies the fixed-point *x* and *y* coordinates corresponding to the `viewRect`.

The ViewAngle function

```
pascal void ViewAngle(angle)
   Fixed    angle;
```

The `ViewAngle` function controls the amount of perspective by specifying the horizontal angle (in degrees) subtended by the viewing pyramid. Typical viewing angles are 0° (no perspective), 10° (telephoto lens), 25° (normal perspective of the human eye), and 80° (wide-angle lens).

The transformation matrix

The transformation matrix allows you to impose a coordinate transformation between the coordinates you plot and the viewing coordinates. Each of the transformation functions concatenates a cumulative transformation onto the `xForm` matrix. Subsequent lines drawn are first transformed by the `xForm` matrix, then projected onto the screen as specified by `ViewPort`, `LookAt`, and `ViewAngle`.

The Identity function

```
pascal void Identity();
```

The `Identity` function resets the transformation matrix to an identity matrix.

The Scale function

```
pascal void Scale(xFactor, yFactor, zFactor)
   Fixed    xFactor, yFactor, zFactor;
```

The `Scale` function modifies the transformation matrix so as to shrink or expand by `xFactor`, `yFactor`, and `zFactor`. For example, `Scale(X2Fix(2.0), X2Fix (2.0), X2Fix (2.0))` will make everything come out twice as big when you draw.

The Translate function

```
pascal void Translate(dx, dy, dz)
   Fixed    dx, dy, dz;
```

The `Translate` function modifies the transformation matrix so as to displace by `dx`, `dy`, and `dz`.

The Pitch function

```
pascal void Pitch(xAngle)
   Fixed    xAngle;
```

The `Pitch` function modifies the transformation matrix so as to rotate `xAngle` degrees around the *x*-axis. A positive angle rotates clockwise when looking at the origin from positive *x*.

The Yaw function

```
pascal void Yaw(yAngle)
   Fixed    yAngle;
```

The `Yaw` function modifies the transformation matrix so as to rotate `yAngle` degrees around the *y*-axis. A positive angle rotates clockwise when looking at the origin from positive *y*.

The Roll function

```
pascal void Roll(zAngle)
   Fixed    zAngle;
```

The `Roll` function modifies the transformation matrix so as to rotate `zAngle` degrees around the *z*-axis. A positive angle rotates clockwise when looking at the origin from positive *z*.

The Skew function

```
pascal void Skew(zAngle)
   Fixed    zAngle;
```

The `Skew` function modifies the transformation matrix so as to skew `zAngle` degrees around the *z*-axis. `Skew` only changes the *x* coordinate; the result is much like the slant QuickDraw gives to italic characters. (`Skew(X2Fix(15.0))` makes a reasonable italic.) A positive angle rotates clockwise when looking at the origin from positive *z*.

The Transform function

```
pascal void Transform(src, dst)
   Point3D   *src, *dst;
```

The `Transform` function applies the `xForm` matrix to `src` and returns the result as `dst`. If the transformation matrix is `Identity`, `dst` will be the same as `src`.

Appendix E

C Compiler Syntax

This appendix describes the syntax of MPW's C compile command.

Syntax	`c [ option ... ] [ file ]`
Description	Compiles the specified C source file. Compiling file *Name*.c creates object file *Name*.c.o. (By convention, C source-file names end in a ".c" suffix.) If no filenames are specified, standard input is compiled and the object file "c.o" is created.
Input	If no filenames are specified, standard input is compiled. You can terminate input by typing Command-Enter.
Output	If you specify the −e option, preprocessor output is written to standard output, and no object file is produced.
Diagnostics	Errors and warnings are written to diagnostic output. If the −p option is specified, progress and summary information is also written to the diagnostic output.
Status	The following status values are returned:

0	Successful error completion
1	Errors occurred

Options	−c	Include comments with the preprocessor output. (By default, comments are not written to the preprocessor output.)

`-d` *name*	Define *name* to the preprocessor with the value 1. This is the same as writing `#define` ***name*** `1` at the beginning of the source file. (The `-d` option does not override `#define` statements in the source file.)
`-d` *name=string*	Define *name* to the preprocessor with the value *string*. This is the same as writing `#define` ***name string*** at the beginning of the source file.
`-e`	Do not compile the program. Instead, write the output of the preprocessor to standard output. This option is useful for debugging preprocessor macros.
`-g`	Generate stack frame pointers in A6 (that is, `LINK A6, x ... UNLK A6`) for all functions. Insert the procedure name into the object code that follows the procedure's `RTS` instruction. Use this option if you plan to debug the program with MacsBug.
`-ga`	Generate stack frame pointers in A6 (that is, `LINK A6, x ... UNLK A6`) for all functions.

`-i` *pathname* [, *pathname*]...

Search for include files in the specified directories. Multiple `-i` options may be specified. At most, 15 directories will be searched. The search order is as follows:

1. The include file name is used as specified. If a *full pathname* is given, then no other searching is applied.

   If the file wasn't found and the pathname used to specify the file was a *partial pathname* (no colons in the name or a leading colon), then the following directories are searched:

2. The directory containing the current input file.
3. The directories specified in –i options, in the order listed.
4. The directories specified in the Shell variable {CIncludes}.

`-o` *objname*	Pathname for the generated object file. If *objname* ends with a colon (:), it indicates a directory for the output file, whose name is then formed by the normal rules (that is, *inputFilename*.o). If *objname* does not end with a colon, the object file is written to the file *objname*.

−p	Write progress information (include-file names, function names, and sizes) and summary information (number of errors and warnings, code size, global data size, compilation time, and compilation memory requirements) to diagnostic output.
−q	Optimize the code for speed, even if it's necessary to make the object code larger. By default, the Compiler performs optimizations that make the code both smaller and quicker; the −q option will perform further optimizations that may make the code faster, but also larger. The −q option should be specified only for those parts of the program that are executed frequently—it's counterproductive to specify −q on code that's rarely executed.
-q2	Allow the optimizer to assume that memory locations do not change except by explicit stores; that is, the optimizer is guaranteed that (1) no memory locations are I/O registers that can be changed by external hardware, and (2) no memory locations are shared with other processes that can change them asynchronously with respect to the current process. This option must be used with extreme caution in device drivers, operating systems, and shared-memory environments, and when interrupts are present.
−s *name*	Name the object code segment. (The default segment name is "Main".) Because a segment may not exceed 32K bytes, large programs require multiple segments with different names. This option is overridden if the following statement appears in the source code: `#define __SEG__ ` *name*
−u *name*	Undefine the predefined preprocessor symbol *name*. This is the same as writing `#undef ` *name* at the beginning of the source file.
−w	Suppress compiler warning messages. (By default, warnings are written to diagnostic output.)
−x6	Use `MOVE #0,x` instructions rather than `CLR x` instructions for nonstack addresses. This option may be useful when writing device drivers.
−x55	Make bit fields of types `int`, `short`, and `char` be signed. (The default is for all fields to be unsigned.)

–z6	Always allocate 32 bits for enumerated data types, to maintain compatibility with Standard C. The default is to allocate 8, 16, or 32 bits. *Caution:* This option is not compatible with the Macintosh Interface Libraries.
–z84	Enable language anachronisms. Warning messages are provided when anachronisms are encountered, and the constructs are compiled.

Example

```
C -p Sample.c
```

Compile Sample.c, producing the object files Sample.c.o. Write progress information to the diagnostic output. (Sample.c is found in the CExamples folder.)

Limitation

One MB of RAM is recommended; on a Macintosh 512K, even small C programs may not compile.

Glossary

***:** A 32-bit pointer data type.

application: A program (such as the MPW Shell itself) that can be launched from the Macintosh Finder.

automatic variable: A dynamic local variable that comes into existence when a function is called and disappears when it is exited.

buffer: An area of memory allocated for reading from or writing to a file.

carriage return (\r): A control code (ASCII 13) generated by the Return key; in MPW C, equal to **newline (\n).**

`char`: An 8-bit character data type whose range is –128 to 127.

command: In the Standard C Library, a parameter that tells a function which of several actions to perform; in the MPW Shell, a command name and parameters.

`comp`: A 64-bit SANE data type with signed integral values and one NaN.

conditional compilation: Use of preprocessor commands (`#if`, `#ifdef`, `#ifndef`, `#else`, `#endif`) to vary what is compiled depending on compile-time conditions.

C SANE Library: A set of routines that provide extended-precision mathematical functions.

C string: A sequence of characters terminated by zero byte.

denormalized number: A nonzero number that is too small for normalized representation.

desk accessory: A program that is accessed from the Apple menu and shares its runtime environment with the currently executing application.

diagnostic output: The file to which MPW tools, including the C Compiler, write error messages and progress information. Diagnostic output appears following the commands being executed in the active window by default, and can be redirected to other files, windows, and selections. In C, diagnostic output is referenced using stream `stderr`.

`double`: A 64-bit floating-point data type—the IEEE `double` type.

`enum`: An enumerated data type of 8, 16, or 32 bits depending on the range of the enumerated literals.

environment: In SANE, consists of rounding direction, rounding precision, exception flags, and halt settings; in MPW, consists of exported variables and signal-handling capabilities.

exception: A special condition recognized in the SANE environment: invalid operation, underflow, overflow, divide by zero, and inexact.

`unsigned long`: A 32-bit integer data type whose range is 0 to 4,294,967,295. Identical to `unsigned int`.

`unsigned short`: A 16-bit integer data type whose range is 0 to 65,535.

`void`: A data type used to declare functions that don't return a value. `Void` may also be used to cast expressions where values are not used.

MPW & MacApp Bug Report Form

BACKGROUND

Date ____________________ Version ____________________

AREA: Compiler: C Pascal

Assembler

Library: C Pascal Assembly

MacApp

Shell/Editor

Tool ____

Performance

BUG DESCRIPTION

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CONTACT INFORMATION

Name: ____________________ Phone/Ext. ____________

Address: ____

City, State, Zip ____

Please return completed form to:
MPW Bug Report; MS 27S; Apple Computer, Inc.; 20525 Mariani Ave.; Cupertino, CA 95014